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RADIO AMATEURS'
MOBILE
HANDBOOK

WILLIAM I. ORR W6SAI

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Covering The Entire Field of Mobile Radio
Antennas - Transmitters - Receivers - Test Equipment

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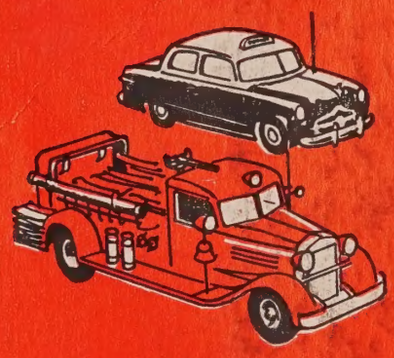

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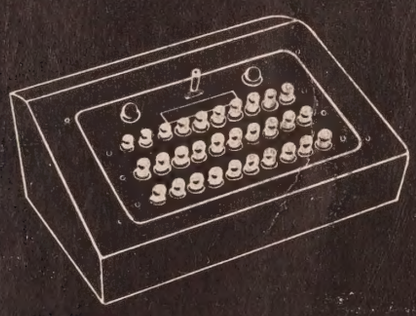

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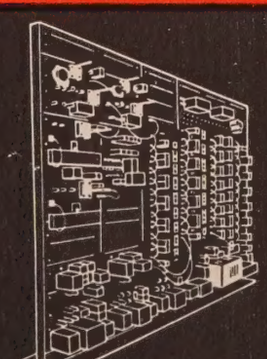

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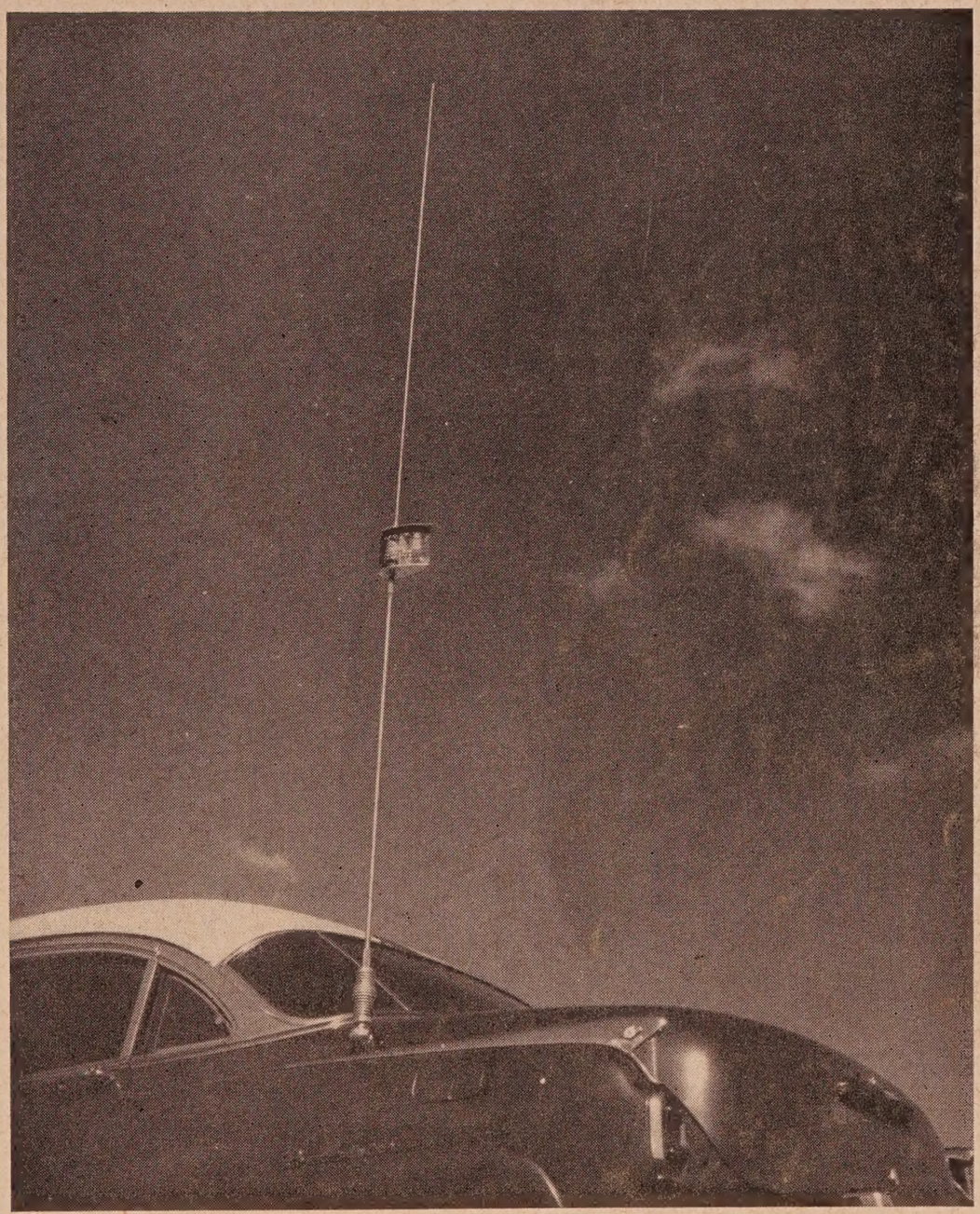

The Sign of a Mobileer

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RADIO AMATEURS'
MOBILE HANDBOOK

by

William I. Orr, W6SAI
Contributing Editor, CQ

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First Edition

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FOREWORD

It has been said that Amateur Radio is the King of hobbies. If this is so, then mobile operation must truly be the sport of Kings!

I remember (to reminisce for a moment) my first attempt at mobile operation. It was in 1934. I had commandeered my father to drive me around town in his 1933 Buick while I struggled with a loop modulated UX-171A operating somewhere in the vicinity of the then ill-defined 5-meter band. I had one intermittent contact over a total distance of some 500 feet, but the thrill of that contact has remained with me to this day.

Those Hams starting to explore the thrills and adventures of mobile operation today will have a much easier road to travel with the knowledge and equipment that is presently at hand. Mobile operation is now a pleasure, rather than a struggle with tubes that were never designed for such service, trunks full of B batteries and floppy antennas that collapsed at the slightest strain.

The purpose of this HANDBOOK is twofold: First, it will provide a source of basic information for the mobile enthusiast that may not be easily obtained. Some of this information has come from companies directly concerned either with automotive electrical systems, or with mobile radio installations; some of it has come from active amateurs, continually experimenting with mobile equipment; and most of it has been learned through the "school of hard knocks." It is hoped that this information will smooth the path and make life a little easier for other amateurs following the same fascinating phase of this hobby.

The second purpose of this HANDBOOK is to describe tried and proven mobile equipment and installations. Some of this equipment has been discussed in CQ magazine. A few pieces has been built by active mobile enthusiasts and appears in the HANDBOOK by invitation, and some of it has been expressly constructed for the HANDBOOK.

I wish to thank the following individuals who have, in one manner or another, contributed time and services toward making this HANDBOOK a success: Al Cline, W6LGU; Bob Hester, W6LYA; Bill Scherer, W2AEF; Ed Kephart, W2SPV; J. G. Rountree, W5CLP; Basil Barbee, W5FPJ; W. C. Ryder, W1JNM; Al Pichitino, WØEDX; and Perry Ferrell, Managing Editor of CQ. To Perry fell the job of editing and fitting this HANDBOOK together. His assistance and moral support throughout this undertaking will always be appreciated.

William I. Orr, W6SAI

Chapter One

Automotive Electrical Systems

1.1—Automotive Ignition System

The purpose of the battery-type ignition system is to furnish a spark to ignite the gas-air mixture in the cylinders of the automobile engine. A voltage of about 6000 volts is usually employed for this purpose. *Figure 1-1-A* illustrates the components and hookup of a typical system using an ignition coil and distributor.

When the ignition switch is closed, the closing and opening of the breaker points controls the flow of current into the primary winding of the ignition coil. This interrupted current creates and collapses a magnetic field in the coil. This field induces a secondary voltage

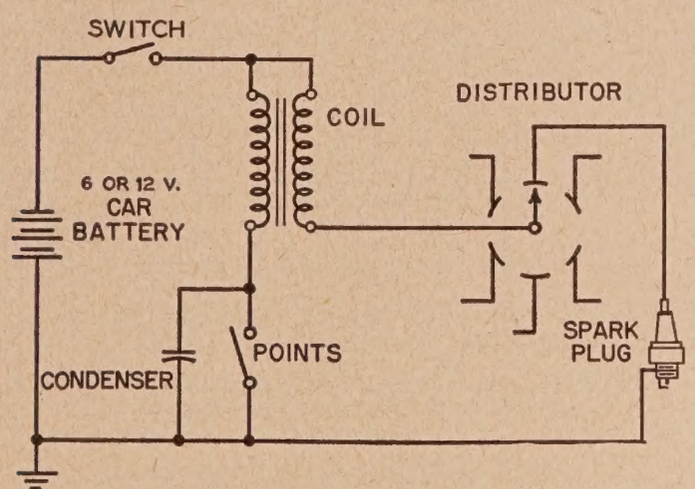


Fig. 1-1-A. A typical six cylinder ignition system.

which is stepped up to the required level and distributed to the correct spark plug at the right time by the distributor. The distributor and breaker are driven by the engine through a gear arrangement, and their speed of operation is controlled by the engine.

The breaker condenser is of the order of 0.25 μfd. Its purpose is two-fold: It regulates the collapse of current in the coil so that the proper amount of energy is developed in the spark, and it protects the breaker contacts from the oxidizing arc developed during operation. A damped oscillatory wave of about 12 kc. is generated by this action. *Chapter 4.0* explains the effect of this wave as a source of ignition interference.

1.2—Voltage Regulators

The usual rating of a car generator is of the order of 30 to 50 amperes. If the generator is not properly controlled, or regulated, it can cause extensive damage to the automobile electrical system and to the battery. The generator can also be burnt out by lack of proper control.

A shunt-wound generator, which is the type usually found in automobiles has voltage and current characteristics that vary greatly with changes in generator speed and load. *Voltage regulation* limits the maximum generated voltage to a preset value to prevent burned out lights and damage to the ignition system and electrical accessories. *Current regulation* limits the maximum output current of the generator and protects the generator against excessive

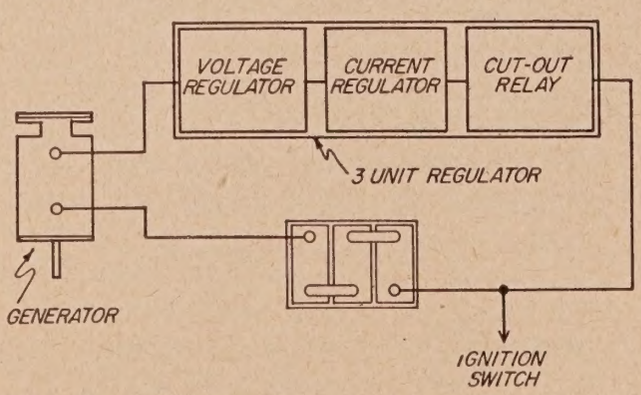


Fig. 1-2-A. Control of the automotive electrical system is usually maintained through a "3-unit" regulator.

loads. A *cutout relay* is used as a reverse current switch for disconnecting the generator from the battery when the generator output voltage is less than the battery voltage. This will prevent the generator from acting as a direct short across the battery, or in some cases behaving like a d-c motor.

Figure 1-2-A shows a typical "three unit" voltage regulator incorporating these three above-mentioned devices. Let us examine each one in turn

VOLTAGE REGULATOR

A two-brush shunt-wound generator is shown in *Fig. 1-2-B*. The voltage produced by this generator is a function of the speed of armature rotation and of the strength of the magnetic field. Since the

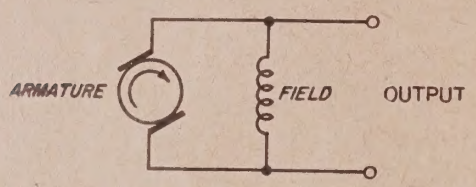


Fig. 1-2-B. The most common automobile generator is a shunt-wound model with the field connected across the output.

speed of rotation depends upon the speed of the car motor, voltage regulation must be accomplished by controlling the strength of the magnetic field. Since the strength of this field is proportional to the amount of current flowing through the field winding, it is practical to control the output voltage of the generator by changing the resistance of the field circuit. This can be done by a field potentiometer, as was done in many of the older cars (*Fig. 1-2-C*). In order to obtain automatic regulation a device is needed which will maintain a constant generator voltage regardless of car speed. A vibrator type regulator is commonly used for this purpose. It does the job by automatically inserting and removing the field resistance at very small voltage differentials (*Fig. 1-2D*). The contacts in such a voltage regulator may operate 200 times a second or more, inserting and removing the field resistance. The contacts are actuated by a voltage sensitive coil placed across the output of the generator. Some regulators

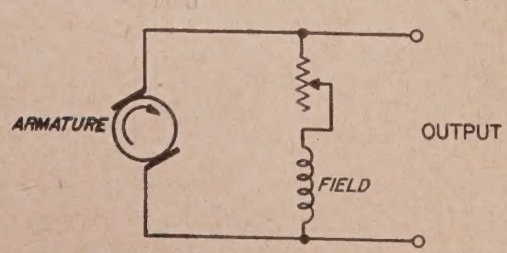


Fig. 1-2-C. Voltage output from a shunt-wound generator may be controlled by a variable resistance in series with the field winding.

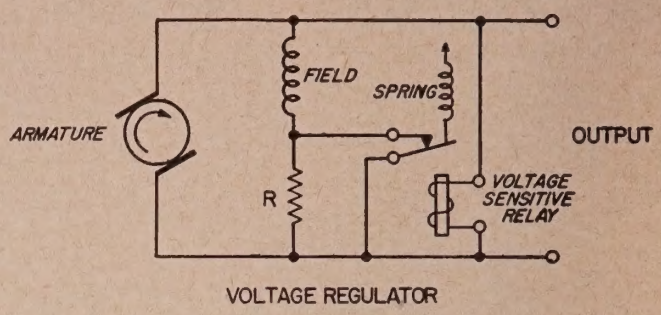


Fig. 1-2-D. The usual automotive practice is to control the voltage output by inserting a fixed resistance in series with the field. The insertion or removal of the resistance is performed automatically by a voltage sensitive relay connected across the generator output.

also have a current coil, sensitive to changes in field current. When the output voltage rises above a certain amount the coil actuates the regulator contacts which open, placing the series resistor, *R*, in the field circuit. This drops the voltage output of the generator. By proper adjustment of the spring of the voltage regulator, the cutout voltage setting of the regulator may be accurately set.

The actual field current flowing during regulator operation is shown in *Fig 1-2-E*. It can be seen that the average value of field current could be regulated by changing the spring tension on the regulator

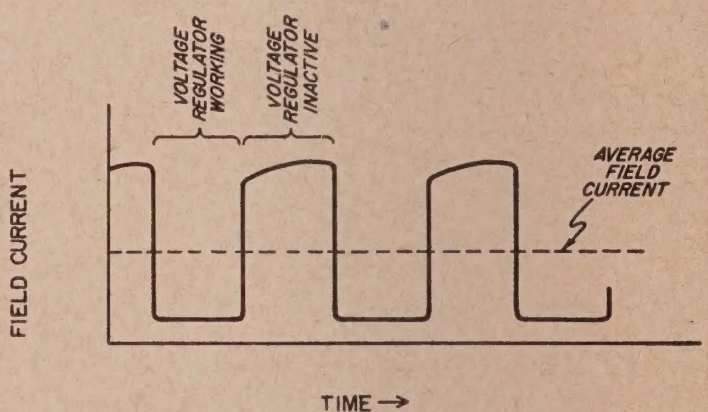


Fig. 1-2-E. The field current, hence the voltage output from the generator varies according to this plot. The rate of change may be as high as 200 times or more per second.

arms. This will change the rate of opening and closing of the resistor shunting circuit.

CURRENT REGULATOR

Current regulation of a two-brush shunt-generator is accomplished in much the same manner as is voltage regulation. *Figure 1-2-F* shows a typical current regulator. A resistance, *R*, is put in series with the field winding, and is intermittently inserted and removed from the circuit by a vibrating regulator. The current regulator winding, however, is inserted in series with the generator load

and is sensitive to load currents, rather than to generator voltage as was the winding of the voltage regulator. This current regulator coil is composed of a few turns of heavy wire, and carries the full generator output current. When the load current is heavy enough, the magnetic pull of the coil will overcome the spring tension and the regulator contacts will open, inserting a regulating resistor into the field circuit of the generator. This will drop the generator output current. This current reduction decreases the magnetic pull of the coil and the relay spring closes the contacts. This action

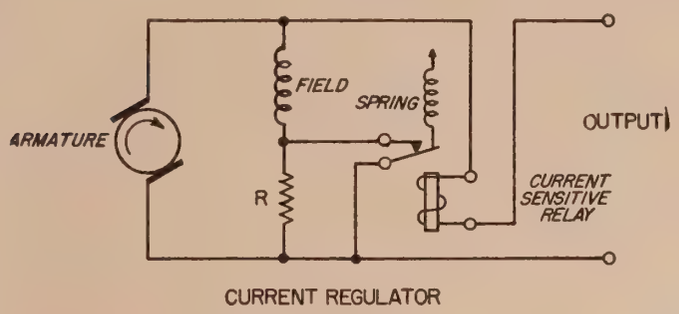


Fig. 1-2-F. The current regulator circuit is essentially the same as the voltage regulator with the exception that the relay coil is in series with the output.

may take place from two to fifty times a second. The result is fairly smooth current regulation.

THE CUTOUT RELAY

The purpose of the cutout relay is to connect the generator to the battery when the generator voltage is greater than the voltage of the battery, and to disconnect the generator from the battery when the generator voltage is less than the voltage of the battery. *Figure 1-2-G* shows the schematic of a cutout relay. A spring holds the relay contacts normally open. The coils *S* and *V* actuate the relay to open and close the contacts. Coil *V* is a voltage coil composed of many turns of

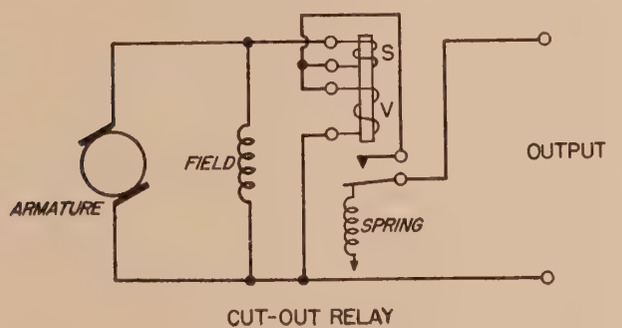


Fig. 1-2-G. The cutout relay consists of a dual winding coil with the relay reacting to both current and voltage. Normally the coils act together to hold the relay closed. When the generator voltage falls below a certain level the curent through coil "S" will flow in a reverse direction, bucking the current (and pull) of coil "V" allowing the spring to pull the relay open.

wire and may be adjusted to close the contacts when the generator voltage is slightly higher than the battery voltage. The generator current, flowing through coil *S*, made of a few turns of heavy wire, adds the pull of this coil to the pull of coil *V*. As the generator voltage falls below the battery voltage, the current flowing through coil *S* reverses its direction and coil *S* bucks coil *V* and reduces the total coil pull enough so that the spring force is sufficient to open the contacts, disconnecting the generator from the battery.

A Combined Voltage and Current Regulator Unit

The two-brush generator requires both voltage and current regulation, as described above. This dual need is met by a single device with the current and voltage regulator relays mounted on one base. The cutout relay may also be mounted on this base. *Figure 1-2-H* shows the active circuit for the assembled three relay unit. To follow the sequence of operation, it should be kept in mind that the voltage and current regulators never operate at the same instant.

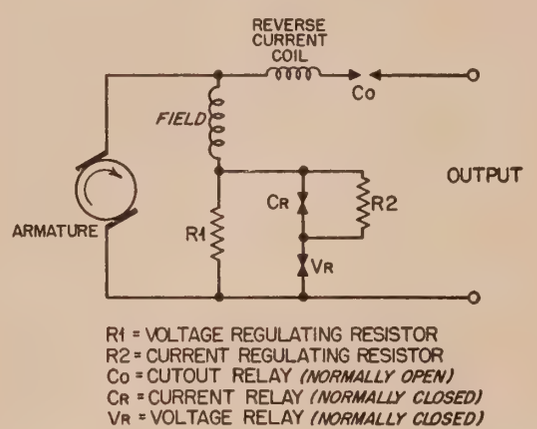


Fig. 1-2-H. Active components in a "3-unit" regulator.

Figure 1-2-J shows a typical regulator layout and connections into the electrical system of the automobile.

Complete Regulator Operation

Assume the voltage regulator is set for 7.3 volts, and that the current regulator is set for 20 amperes. The operation will follow this sequence:

1. The car engine is started.
2. The engine speed is increased, the generator voltage increasing simultaneously.
3. When the generator voltage reaches 6.3 volts, the cut-out contacts, *Co*, close, allowing the generator to charge the battery.
4. When the generator voltage reaches 7.3 volts, the voltage regulator contacts, *Vr*, operate and maintain generator voltage at

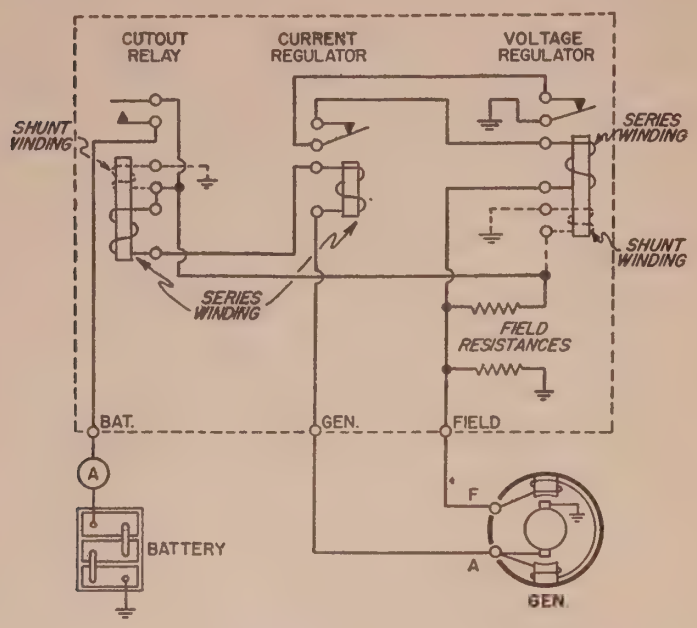


Fig. 1-2-J. Pictorial schematic of a typical regulator installation in most automobiles.

7.3 volts, plus or minus 0.15 volts, regardless of the car speed or generator load.

5. If the generator load current exceeds 20 amperes because of a low battery or excessive load from headlights or electrical accessories, the current contacts, *Cr*, operate and limit the generator current to 20 amperes regardless of generator speed. The remainder of the load current is supplied by the car battery.
6. When the engine speed falls below about 8 miles per hour the cutout contacts open and disconnect the battery from the generator.

1.3—Regulator Adjustment

The addition of mobile equipment to an automobile means that the electrical system of the car will be called upon to deliver some 15 to 50 amperes during transmission periods, and perhaps 10 amperes during receiving periods. This assumes that indirectly heated tubes are used and that the car broadcast receiver is used in conjunction with a converter. The regulation devices in the car are usually not adjusted to take this magnitude of load and continued use of the mobile equipment may soon result in a discharged storage battery. However, by properly adjusting the current and voltage regulators in the automobile a power load of this order can be safely handled with no danger to either the automobile battery or charging equipment.

Adjustment of the Cutout Relay

Proper adjustment of the cutout relay may be made by measuring the voltage between the "GEN" terminal of the regulator and ground with the engine idling. This voltage will be anything between zero to about five volts. *Slowly* increase engine speed, noting the voltage at which the cutout relay closes. This should be in the range of 6.0 to 6.5 volts. Adjust the spring tension of the cutout relay if necessary to obtain this reading. Increasing spring tension raises the reading, decreased tension lowers it.

Adjustment of the Current Relay

Proper setting of this relay, usually the center one of the three relays and wound with heavy wire, can be done by inserting an ammeter between the "GEN" terminal of the regulator and the "A" terminal of the generator. Adjust the spring tension of the current relay to cause the relay to open at the rated current output (see nameplate) of the generator. Increasing the spring tension raises the opening current. Some regulators have adjustment screws, others require bending of the tab to which the spring is fastened. Bend this very carefully and very little at one time. When you have this adjustment correct, the generator will charge to its maximum capacity without exceeding its safe operating limits. During the above operation the armature of the voltage regulator should be held so that it cannot be operated by its magnet.

Adjustment of the Voltage Regulator

The usual voltage regulator setting is barely high enough to keep the automobile battery fully charged under normal circumstances. The regulator is set at the factory to reduce the charging current to zero when the battery is not quite fully charged. With this adjustment the generator will not charge to full capacity until the battery drops to a half-charged condition. The battery will seldom rise above this point with ordinary city driving because of the tapering effects of the regulator. By adjusting the spring tension on the voltage regulator the "fully charged" current may be raised. If the regulator is adjusted to deliver about 10 amperes to a *fully charged* battery, the normal use of the mobile equipment will adjust a higher level of equilibrium and the battery will remain nearly fully charged at all times. On long trips, however, if the mobile equipment is not used to compensate for this higher charging rate it may be necessary to turn on the radio or headlights to prevent overcharging of the car battery. For the usual city driving of short duration this is not necessary.

The following are the adjustments to increase the charging rate. Be sure your battery is *fully charged* before making these adjustments:

1. Wedge the armature of the current coil so that it is inoperative.
2. Speed the engine and note at which current point the action of the voltage regulator levels off the charging current. (The current should be measured on a 0-50 ammeter placed in series

with the heavy charging lead from the battery to the generator.)

3. Adjust the spring tension on the voltage regulator relay until this levelling action occurs at a charging rate of 10 amperes. Make this adjustment carefully, changing the spring tension slowly. This levelling action occurs at a charging voltage of 7.2-7.3 volts.

These adjustments should only be done after the underhood temperature is up to normal. Most regulators have temperature compensating hinges and all adjustments must be made with the regulator at operating temperatures.

Correct setting of the voltage regulator will be denoted by a specific gravity reading of 1.250 to 1.275 of the battery at all times and little use of water. Under ideal conditions the car ammeter needle should move to full charge immediately after starting the car, and remain there for perhaps five minutes, then fall to a minimum charge determined by the spring adjustment described above.

Operate the vehicle for a week or so, then check the specific gravity of the battery again. If it is in the range of 1.250 to 1.275, and the dashboard ammeter behaves as described above, the job is finished. If the gravity is too low, recheck the levelling action, and perhaps adjust it at a slightly heavier rate, say 12 amperes.

1.4—Care of the Car Battery

The operation of the automotive type storage battery is a chemical reaction involving lead, lead oxide and sulfuric acid. During discharge the above components recombine to form lead sulfate and water. The water formed dilutes the sulfuric acid electrolyte, thus reducing the specific gravity of the cell. On charging the chemical reaction is reversed. When overcharged beyond the point necessary to complete

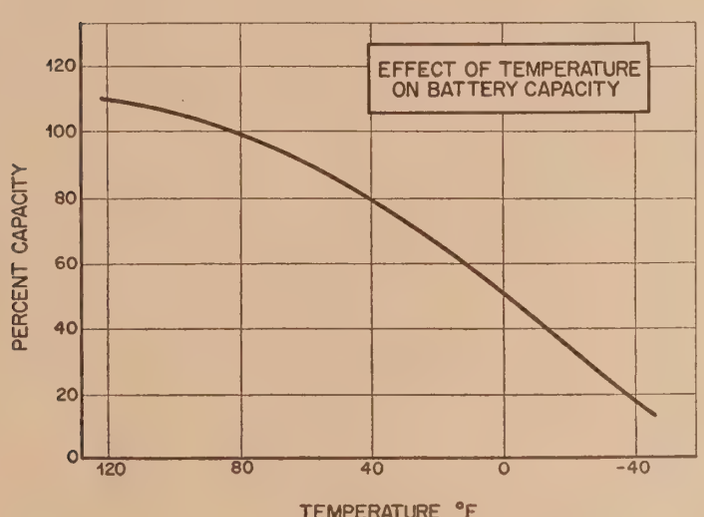


Fig. 1-4-A. Battery temperature has a pronounced effect upon battery capacity. This graph shows the decrease in capacity as related to temperature.

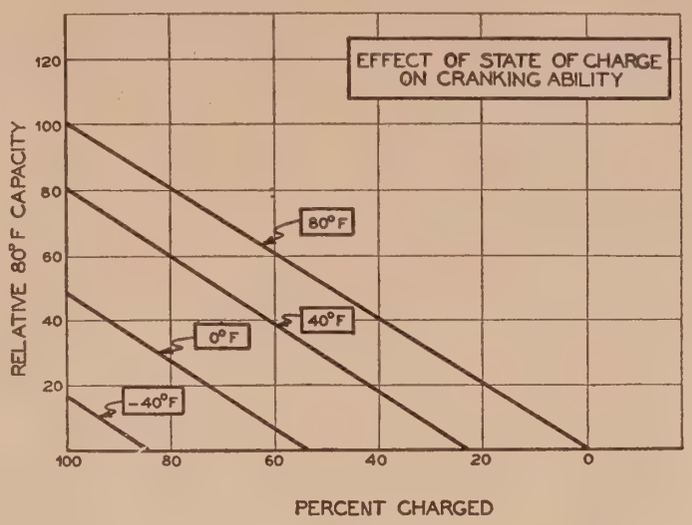


Fig. 1-4-B. The effects shown in Fig. 1-4-A were measured for a fully charged battery. If the battery has only a partial charge the effects of low temperatures may be even more disastrous.

the chemical reaction, the water content of the electrolyte is reduced by electrolytic decomposition. Hydrogen is liberated at the cathode while oxygen is liberated at the anode; both of these gases bubble from the liquid and are lost, thereby necessitating the water additions.

The capacity of a battery to store electrical energy is controlled by the quantity of ingredients available for chemical reaction—i.e., the size and number of plates. The ability of the battery to deliver high rates of current flow is limited by its internal resistance—i.e., plate area. Thus, it can be seen that the larger physical-sized units store more energy and can deliver it at higher rates than smaller units.

It must be borne in mind, however, that even a large size automotive-type battery stores a surprisingly small amount of energy. For example, a fully charged De Luxe battery of 120 ampere-hour rating would operate the modern car with its high electrical load only about 1 to 2 hours before becoming exhausted. This dramatically illustrates the fact that, in your car electrical system, the battery really plays a relatively unimportant part since without charging equipment its life would be woefully inadequate.

The greatest portion of battery failures occur during cold weather. The reason for this can be readily seen by referring to *Fig. 1-4-A*. This curve shows the effect of temperature on battery capacity.

The first 20° F. day of Fall reduces the capacity of your battery to approximately 2/3 of normal. Further, if your battery was only half charged to begin with, this capacity falls to only about 20% of normal! This further reduction can be seen from the curves of *Fig. 1-4-B*. The obvious moral of this story is—keep your battery fully charged at all times.

In addition to the ability of the battery to crank your car at any given moment, the correct state of charge has an important influence on

the life of your battery as illustrated in *Fig. 1-4-C.* Here is can been seen that too high a regulator setting causes overcharge or sulfation, reducing battery life about 50%.

Recently, a major battery manufacturer made a survey of junked car batteries to determine the cause of failure. The results of this survey are given in the table below:

Still Serviceable	13%	Cracked Separators	3%
Overcharged	55%	Container Failures	10%
Sulfated	18%	Manufacture Faults	1%

Examination of this table reveals the following facts: that 68% of the batteries checked failed as a result of malfunction of the *other* components of the car electrical system; a cause

A handy item for those fellows who want to be sure of the water level in their batteries is a set of Hydrocaps. A catalyst in the cap converts the escaping gases back into water. Battery inspection becomes quite infrequent when Hydrocaps are used properly.

that could have been readily avoided by adequate maintenance. Your part in this effort is to keep the battery water level as called for by the manufacturer, keep the battery clean and properly fastened in its carrier, and finally, keep the charging equipment in proper adjustment.

Care of the Battery

1. The electrolyte in the battery should be maintained at the proper level. It should be checked at least once a month in winter, every two weeks in summer, or every 1000 miles.
2. Do not overfill the battery.
3. The charge of the battery should be checked frequently with a hydrometer. The state of charge is indicated by the reading:

1.250-1.300	:	Fully charged
1.225	:	Half charged
1.150	:	Very low

4. A fully charged battery will not freeze in temperatures usually encountered. A battery with 1.150 specific gravity will freeze at 5°F., and a battery with 1.100 specific gravity will freeze at 18°F.
5. The terminal connectors of the battery should be removed, cleaned and inspected regularly. The connections must be secured tightly when replaced, or excessively high generator output may cause damage to the ignition system.
6. Apply a coat of vaseline or petroleum jelly to the terminal connectors of the battery to protect them from corrosion.

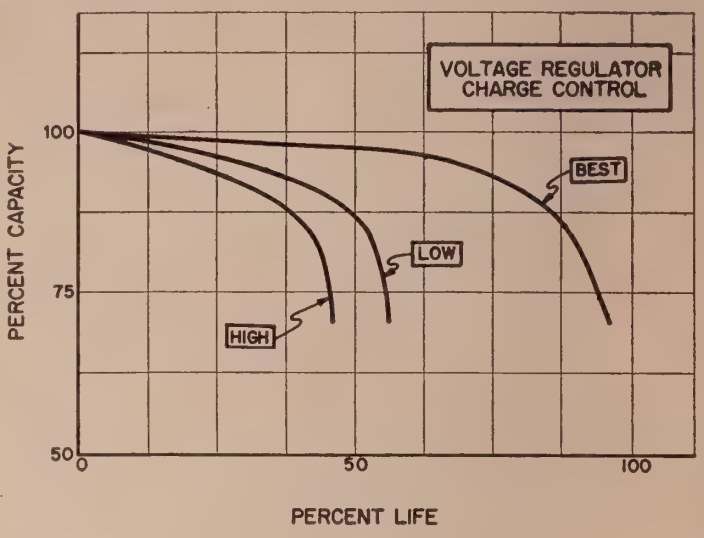


Fig. 1-4-C. The voltage regulator setting has an important influence on battery life. Too high, or too low, a setting may result in a substantial loss of battery life.

Chapter Two

Mobile Power Supplies

2.1—Mobile Power Supply Requirements

Unlike fixed equipment, mobile transmitters must be designed around their power supplies. Mobile supplies, such as dynamotors or vibrator supplies provide certain fixed voltages with appropriate current limitations. One cannot add an input condenser to the filter supply to boost the available voltage, or merely put in a larger power transformer to supply more current. A change of supply voltage in mobile work usually necessitates a completely new source of power. This is expensive, so it is necessary to design the mobile equipment around some rather standardized voltages and currents that are readily available.

Two popular methods of obtaining high-voltage are the dynamotor and the vibrator supplies. Let us critically examine each one of these sources and determine under what circumstances it is wise to use each of them.

2.2—Vibrator Power Supplies

The basic design of a vibrator type power supply consists of a common a-c operated supply, with an interrupted d-c primary voltage supplied by a battery and a chopper. The chopper (or vibrator) makes and reverses the primary circuit of the power supply about 100 times per second. The alternating field produced in the power transformer induces a square wave alternating voltage in the secondary windings. This voltage may be rectified and filtered as in the usual high voltage supply.

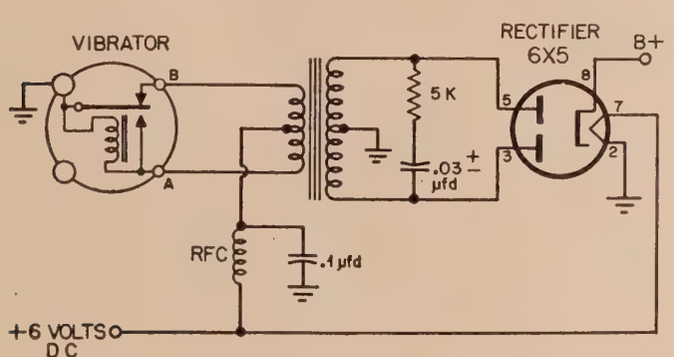


Fig. 2-2-A. This is a typical schematic of a non-synchronous vibrator power supply. The "reed" in the vibrator normally rests against "B" and when attracted towards "A" it automatically shorts out its own magnetic pull. Pulses of current are fed into the transformer.

Two types of vibrators are in common use. The simplest is the non-synchronous type, illustrated in *Fig. 2-2-A*. Upon application of battery power the magnet coil is energized and pulls the flexible reed towards contact *A*. This contact produces a pulse of voltage in one half of an external transformer primary winding. At the same time, the magnet coil is short circuited by the contact and the magnet is de-energized, allowing the reed to swing back and touch contact *B*. This contact causes a pulse of voltage in the other half of the primary winding. Simultaneously, the magnet coil is energized, causing the cycle to repeat itself. The secondary output voltage is shown in *Fig. 2-2-B*.

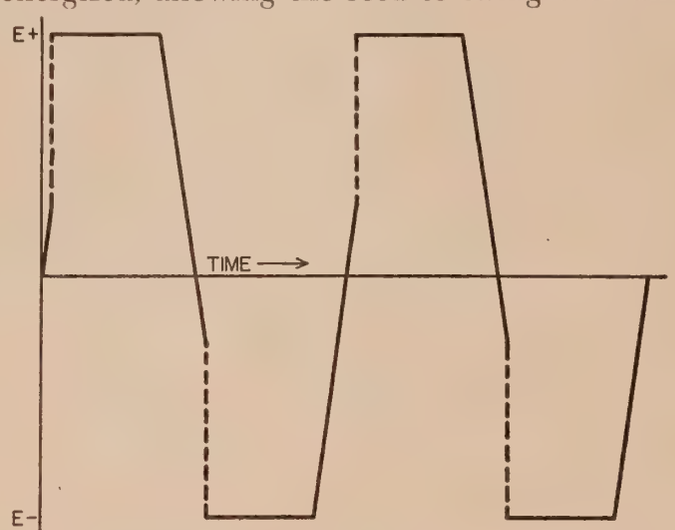


Fig. 2-2-B. The voltage waveform in the transformer secondary circuit appears to have the shape indicated above when the timing capacity is properly set.

The second type of vibrator *(Fig. 2-2-C)* is the synchronous type, equipped with double contacts. The second set of contacts, operating on the high voltage secondary act to rectify the secondary square wave voltage. This mechanical rectifier eliminates the high voltage rectifier

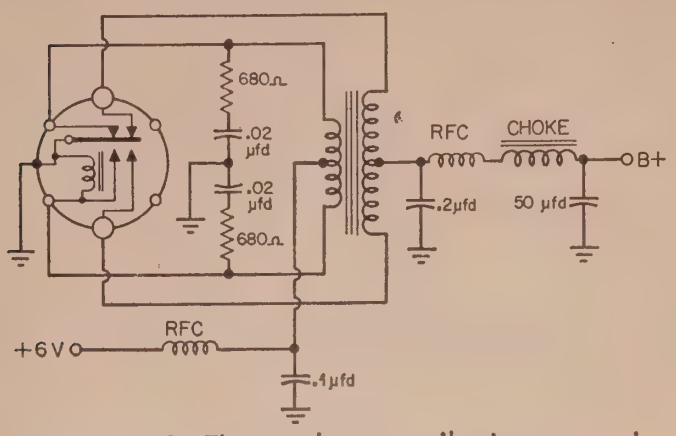


Fig. 2-2-C. The synchronous vibrator power is self-rectifying due to the use of a double set of vibrator contacts. Through proper polarization of the transformer windings this mechanical rectification is possible.

tube. The positive high voltage is taken from the transformer center tap, and the transformer windings must be correctly polarized.

For either type of vibrator a buffer condenser is needed across the full secondary winding. This condenser absorbs the inductive surge of the power transformer and reduces sparking at the vibrator contacts. The correct value of this condenser is the one which results in the lowest value of primary current drain when the vibrator supply is operating under full load. The condenser should be rated at 2000 volts d.c. for the usual 300-volt supply. A 5000-ohm 1-watt resistor should be placed in series with the condenser to protect the transformer and vibrator in case of failure of the condenser.

Vibrator Noise Suppression

A vibrator supply is a prolific hash generator. The commercially manufactured vibrator supplies are specifically filtered and shielded to minimize this noise. A home-made supply should have the following steps included for correct suppression of noise:

1. The supply should be built on a metal chassis with a bottom plate. All unshielded components should be mounted inside the chassis.
2. Primary and secondary r-f filter should be used, consisting of chokes and low inductance capacitors.
3. The vibrator shell and transformer case should both be securely grounded to the chassis. A metal rectifier tube should be used. If a glass tube is used, it should have a grounded tube shield over it.
4. The primary supply leads should be twisted and shielded, with the shield grounded.
5. The chassis of the supply should be grounded to the car.

A schematic of such a supply is shown in *Fig. 2-2-D.* The operating characteristics of a typical vibrator supply *(Mallory VP-552)* are shown in *Fig. 2-2-E.*

Operating Tube-Rectifying Vibrator Power Supplies on 115 volt AC lines

Some vibrator supplies are equipped with a

C1, C2, C5—0.5 μfd., 50v. coaxial, Sprague 48P18.
C3—Approximately 0.007 μfd., 1500-volt paper. Capacity to be adjusted for lowest battery drain at maximum secondary load, Cornell-Dubilier Type PTE.
C4—0.01 μfd., 600v., coaxial, Sprague 47P6.
C6, C7—20.0 μfd., 400 v., Sprague TVL-1660.
C8, C9—0.001 μfd., ceramic, Erie 801-001.
CHOKE—10 h., 110 ma., Stancor C-1001.
R1—3300 ohms, 1w.
RFC1—4.0 μh., 6 amperes, Miller 5221.
RFC2—2.5 mh., 100 ma., National R-100.
RFC3—4.0 uh., Miller #5221.
S1—Switch, ICA #1281.
T1—330-0-330 volts., Stancor T6131.
F—Fuse, 10 amp.
P1—Socket S402AB with P402CCT plug (Cinch-Jones).
P2—Socket S303AB with P303CCT plug (Cinch-Jones).
V—Vibrator, Mallory #294 with #GC-7 grounding cup.

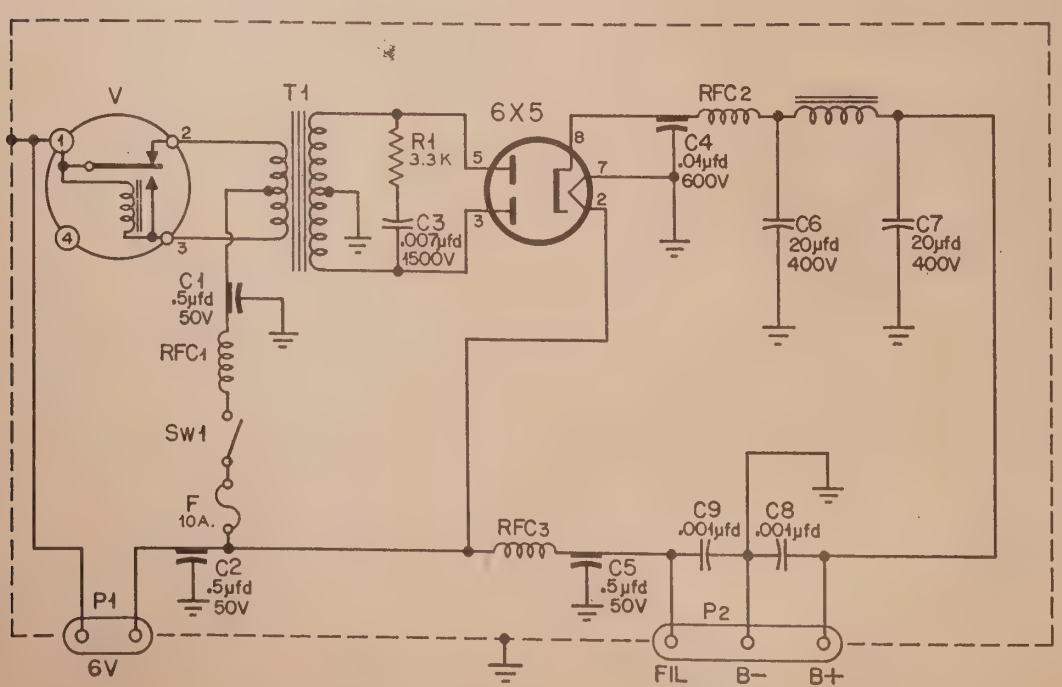


Fig. 2-2-D. Wiring schematic of a non-synchronous vibrator power supply. Note that the entire unit must be thoroughly shielded for maximum "hash" suppression.

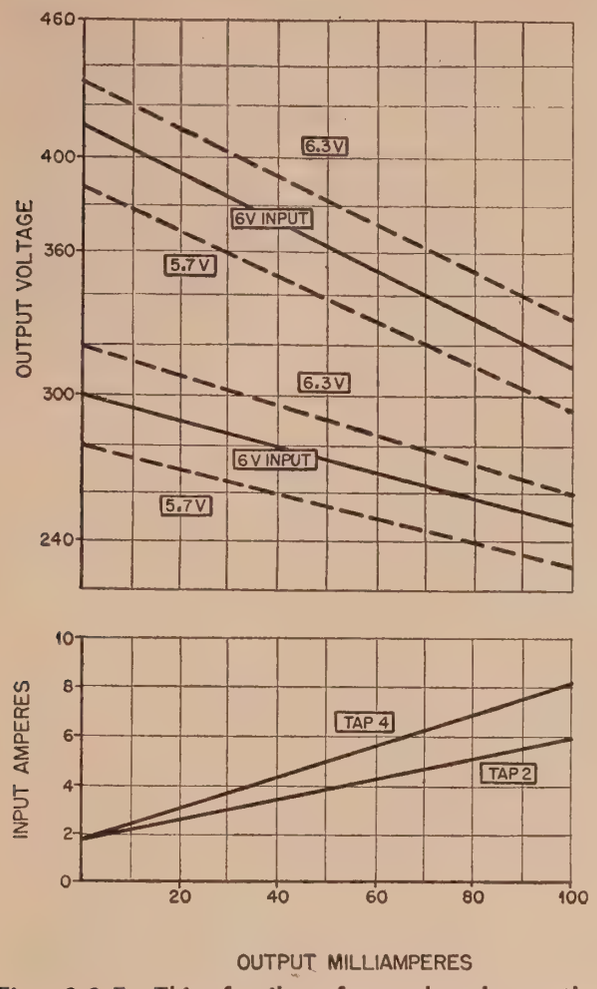
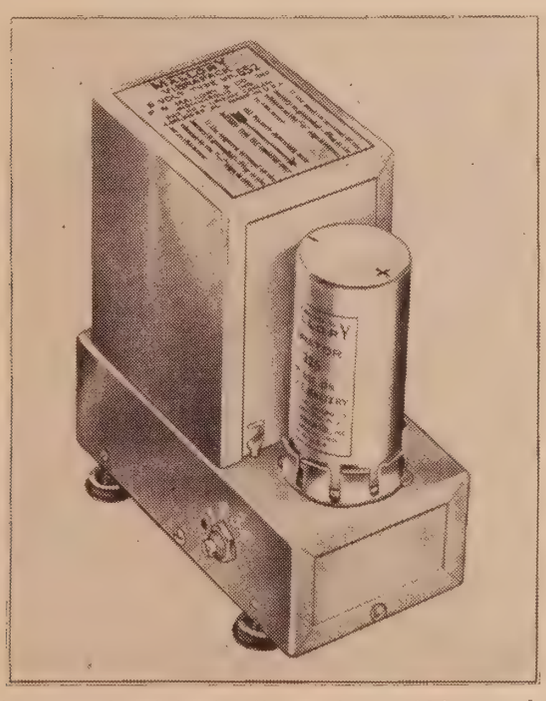


Fig. 2-2-E. This family of graphs shows the operating characteristics of the VP-552 Vibrapack.
(Courtesy P. R. Mallory & Co.)

special 115-volt primary winding. If the vibrator is removed, the supply may be used on 115-volts, a.c. The additional winding is expensive and takes up room on the transformer core, so most vibrator transformers do not have it. The absence of this winding does not prohibit the use of the vibrator supply on an a-c line. If a step-down transformer is available which will supply 10 volts a.c. at the load current required, easy adaptation of standard 6-volt tube rectifying vibrator power units will be possible. The 10 volts a.c. is applied to the vibrator transformer across the entire primary winding by removing the vibrator and inserting an adaptor having the 10 volts connected to the two small pins of the standard vibrator base, or to the equivalent pins of an unconventional base, if one is used. The value of 10 volts is used instead of 12.6 volts as would be suspected, because of the difference in waveform between the sine-wave a.c. and the square wave d.c. The tube heaters may be run from the 10-volt source through a suitable dropping resistor.

Operation of a vibrator supply on an a-c line is of a great help during the testing and trial runs of new equipment.



This popular P.R. Mallory VP-552 Vibrapack has the load characteristics shown in the graph at the top of this column.

2.3—A Vibrator Supply Using Selenium Rectifiers

A novel and highly efficient vibrator supply may be built using a selenium rectifier bridge in the place of the usual high voltage vacuum rectifier tube. The selenium bridge has several advantages over the tube rectifier which make it very worth while for mobile use:

1. In a typical vibrator supply, such as shown in *Fig. 2-3-A,* only half the transformer is in use at any one time. It is possible to make full use of the transformer by using the bridge circuit shown in *Fig. 2-3-B.* The secondary winding of a bridge transformer requires only 70% of the space required for the equivalent output from a center tapped full wave secondary winding.
2. The use of selenium rectifiers offers improved voltage regulation, as compared with vacuum rectifiers, since the forward resistance of the selenium rectifier is extremely low. The regulation of this supply, compared to a vacuum tube rectifier supply is shown in *Fig. 2-3-C.*

Such a supply was described in the *General Electric Co. "Ham News"* publication of March/April, 1953, and is redescribed herewith by permission of the *General Electric Co.*

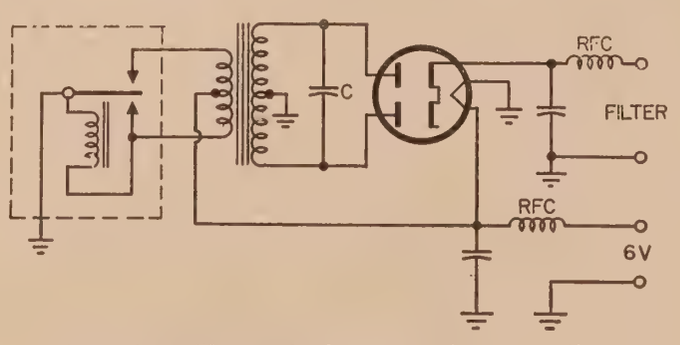


Fig. 2-3-A. The typical non-synchronous vibrator employs only one-half of the transformer at any given instant. A saving in space and weight can be made through the use of a bridge type circuit.

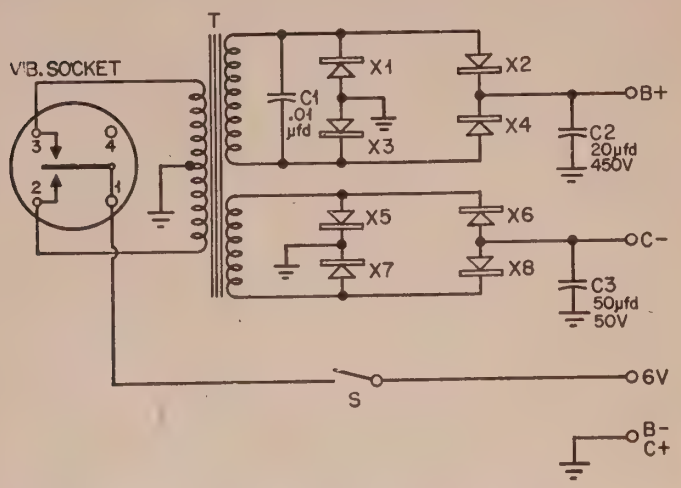


Fig. 2-3-B. Circuit diagram of the bridge type selenium rectifier using a non-synchronous vibrator. The transformer is described in the text. The rectifiers X1 to X4 are 100 ma. models such as the GE-6RS5GH1. Rectifiers X5 to X8 are modified as indicated in the text.

Components

The special vibrator transformer used in this supply has a high voltage winding rated at 300 volts and 100 milliamperes, and a bias voltage winding for supplying minus 40 volts. This bias winding may be used to provide a convenient bias supply for class B audio systems, or as safely bias for r-f stages. The transformer is manufactured by *Ballastran Corp., 1701 N. Calhoun St., Fort Wayne 7, Indiana.*

The buffer condenser, *C1,* is a 400-volt unit, since the voltage peaks appearing across it are of relatively low amplitude.

The waveform of the secondary voltage is essentially square in shape and only a single filter condenser is needed to convert this to d-c. The usual iron core filter choke in the high voltage lead may be omitted.

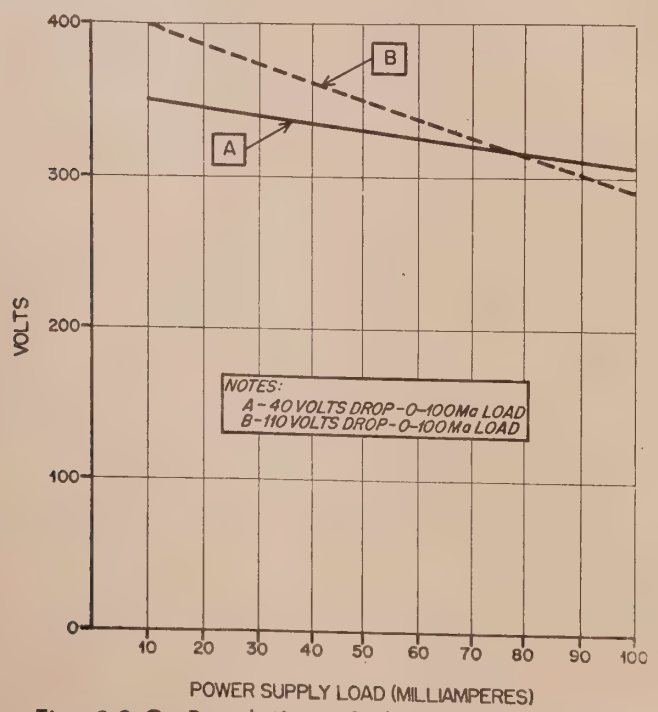


Fig. 2-3-C. Regulation of the selenium bridge supply (curve A) compared with the vacuum tube rectifier supply and conventional system (curve B). The efficiency of the supply is about 67% and the ripple content is 0.25 volts.

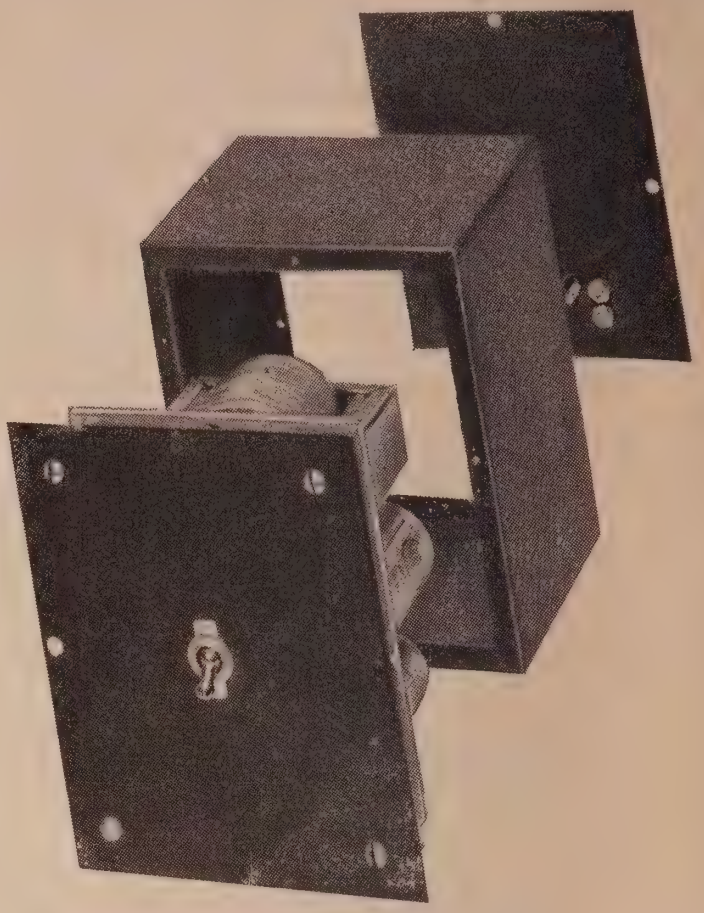


Fig. 2-3-D. The selenium bridge vibrator supply may be conveniently built into a utility box. *(Courtesy G.E. Co.)*

Construction Details

The power supply illustrated in *Fig. 2-3-D* fits into a 4 x 5 x 6 inch utility box *(Bud CU-729),* with an off-on toggle switch on the front and a 4-terminal barrier type strip on the back. All other components are mounted on a plate of ⅛ inch aluminum which just clears the lips of the utility box and stands off 1 inch behind the front cover as shown in *Fig. 2-3-E.* The 50 μfd. bias filter condenser is mounted under the plate between a terminal lug and one of the ground lugs at the base of the high voltage filter condenser.

Aside from careful placement of the components to get them all in the box, the only critical construction problem is the modification of a fifth selenium rectifier to provide the bridge circuit for the bias voltage.

This small bridge is the four plate stack seen at the left in *Fig. 2-3-E.* The first step in taking apart a *Model GE-6RS5-GH1* rectifier is to pry up the washer clamp at the top. The plates may then be easily separated with a knife blade. Care must be taken not to disturb the "spider"

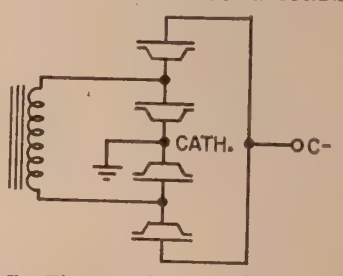


Fig. 2-3-F. The cathodes (the spiders of the GE-6RS5GH1) of the rectifiers are joined in the center and grounded.

sealed to each plate. Insert the knife blade between spider and adjoining washer—not between spider and plate.

The rectifiers are marked with a dot of red on the cathode terminal, to which the associated B plus leads are attached. In making up the small bias bridge, it is important to note which sides of the plates are cathodes. In the *GE-6RS5-GH1,* the "spider" is sealed to the cathode. Thus to make a full wave bridge with one plate in each leg, four of the plates are restacked with washers and suitable lugs. Note that the cathodes are joined in the center and grounded as indicated in *Fig. 2-3-F.*

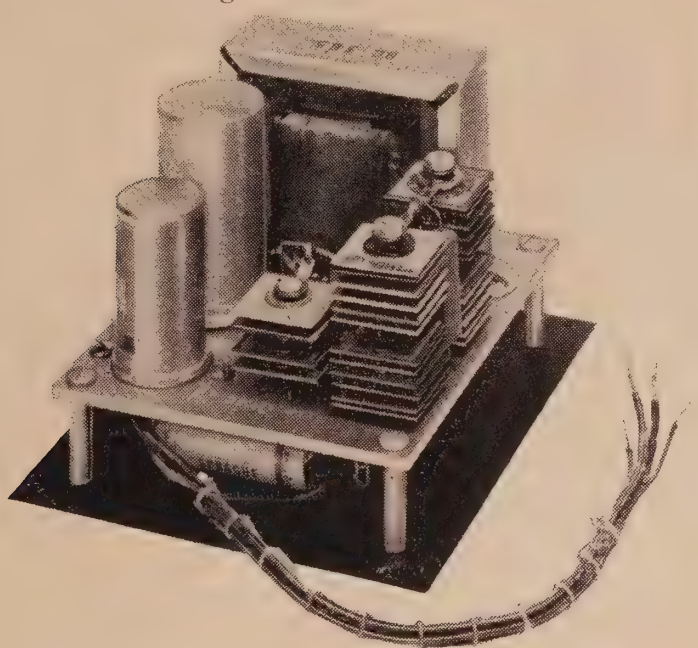


Fig. 2-3-E. The modified selenium rectifiers X5 to X8 are shown in this photograph in the center of the deck. The plates are clearly visible. *(Courtesy G.E. Co.)*

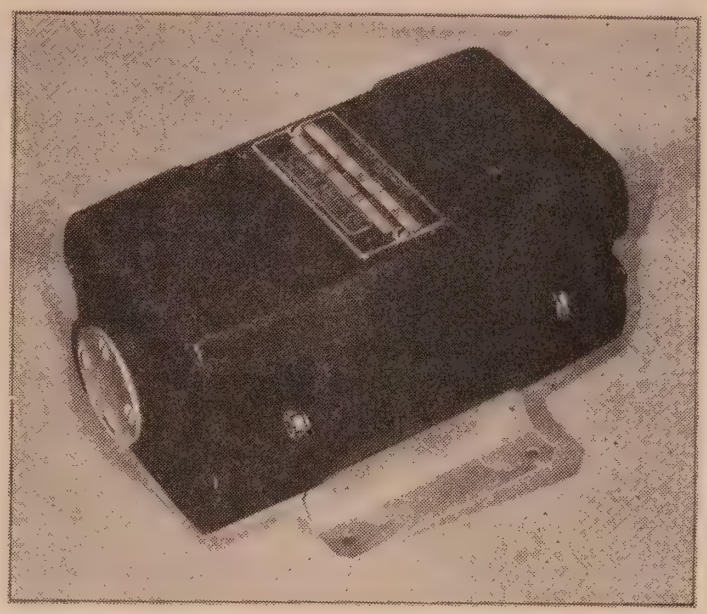
2.4—Dynamotors

A dynamotor is a motor driven d-c generator which converts low voltage direct current to high voltage direct current. Unlike a motor generator, the low-voltage and high-voltage windings of the dynamotor are mounted on and around one shaft as an integral unit. The efficiency of a good dynamotor is slightly less than that of a vibrator power supply, running about 55-60%. This is because the dynamotor must draw enough extra power from the primary source to keep the armature rotating.

Dynamotor Maintenance

If the dynamotor is operating properly and does not run excessively warm, it should rarely be touched. Sanding of the commutator, manipulation of the brushes or excessive greasing is likely to do more harm than good.

A routine inspection once every two weeks should consist of a check as to whether or not the brushes are free in their holders, and a cleaning of the carbon or copper dust which may have accumulated in the vicinity of the commutator. If the voltage output is below normal remove the brushes and check each coil winding of the armature for an open or short

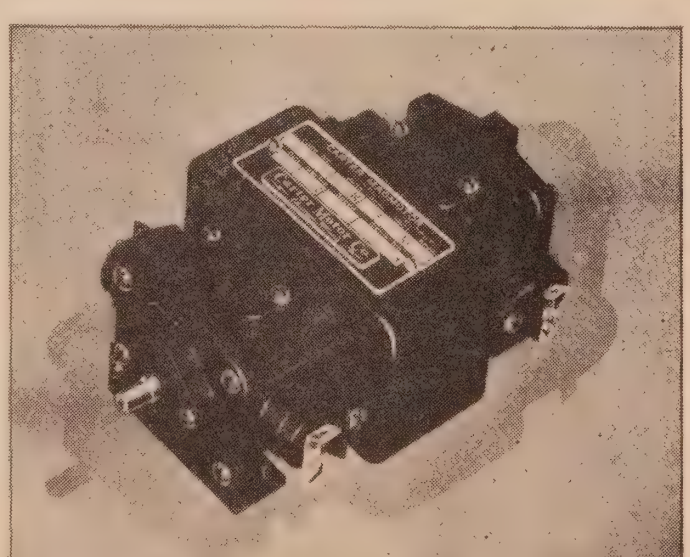


This 3-inch frame genemotor is very popular in mobile radio installations. *(Courtesy Carter Motor Co.)*

circuit. This is accomplished by placing the prods of an ohmmeter on adjacent high-voltage commutator bars and continuing the test around the commutator. The prods should not be applied to the commutator surface that comes in contact with the brushes. The high voltage windings will have a resistance in the range of 5-30 ohms. The low voltage windings must be measured on a bridge, as they run only a few tenths of an ohm. The d-c resistance of the shunt field is of the order of 100 ohms or so.

Brushes

Low voltage brushes have a useful life of about 1000 hours of operation. High voltage brushes should last somewhat longer. The end of the useful life of the brushes comes when they have worn down to a length of about ¼". When new brushes are installed, the commutator should be carefully sanded with grade 0000 or finer sandpaper. The dynamotor should be "run in" for about six hours until at least 80% of the surface of the new brushes is in contact with the commutator.



For low power consumption a Carter Magmotor is often the most suitable high voltage supply. *(Courtesy Carter Motor Co.)*

Operation

The dynamotor should be operated with adequate ventilation. Most dynamotor failures occur because of overheating due to overload or inadequate ventilation. If the dynamotor is located in the turtleback of an automobile the operating temperature will quickly exceed the danger point during warm weather. To help cool the dynamotor, the end bells should be removed. A small, 6-volt fan can be so located as to pass air through the interior of the dynamotor and will help in keeping the operating temperatures in the safe region.

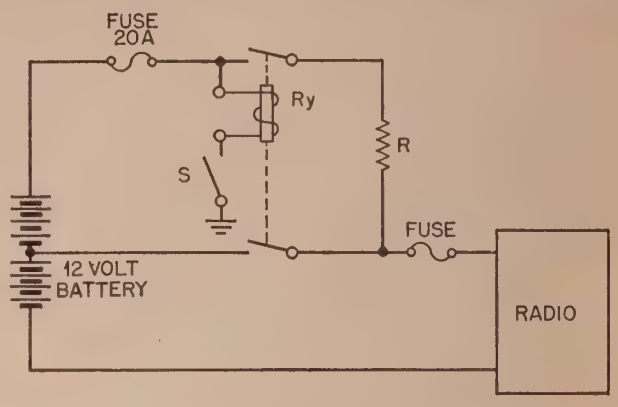
2.5—12 to 6 Volt Modification Systems

Today, with the automotive industry gradually changing to a 12-volt battery system, mobile operators are faced with the problem of what to do with their present 6-volt rigs when they purchase a new car. Probably the first and most logical idea is to convert the present rig to 12-volt operation. The filament strings can be rewired to operate series-parallel on 12 volts. If a vibrator supply is used, it will be necessary to obtain a 12-volt vibrator and a new transformer. If a dynamotor is used, and if the field structure of the dynamotor was designed with a high enough factor of safety, such that it will not overheat when operated on 12 volts, it is only necessary to purchase a new 12-volt armature and a new set of 12-volt brushes. The 6-volt dynamotor will then operate properly on 12 volts, providing the same output voltages as it did on 6 volts.

The above conversions may require a good deal of work, and an alternative method is to obtain a 6-volt source of power and continue to use the 6-volt equipment "as is."

Use of a Resistor for 12 to 6 Volt Reduction

A simple method of accomplishing the desired voltage reduction is by means of a resistor and relay combination *(Fig. 2-5-A)*. This system requires a 6-volt tap on the 12-volt battery, from which tap the 6-volt equipment may be run. When switch *S* is closed, the relay connects the 6-volt lead to the equipment, at the same time shunting a compensating resistor, *R*, across the remainder of the battery. The resistor and radio set now form a voltage dividing network across the 12-volt battery. By proper selection of the resistance value, the two sections of the battery will be kept equally charged at all times.



Ry-DPST 12 VOLT RELAY
S-ON-OFF SWITCH
R-DROPPING RESISTORS (SEE TEXT)

Fig. 2-5-A. This is a suggested method of converting the 12-volt electrical automobile system to operate a 6-volt transmitter.

As an example, assume the rig draws 10 amperes in the receive position, and 30 to 40 amperes in the transmit position. Since the receive time is usually much more than the transmit time, 12 to 14 amperes flowing in the resistor will probably keep the battery sufficiently charged. Two 1-ohm 50-watt resistors in parallel will do the job. Occasional checks on the condition of the battery should be made, and slight adjustments made to the value of the resistor if one section of the battery remains higher charged than the other.

In order to reduce the obsolescence of 6-volt mobile equipment the Carter Motor Co. has announced their "Change-a-volt" dynamotor. This unit will provide 6 volts at 45 amperes from the 12-volt system in the newer automobiles.
(Courtesy Carter Motor Co.)

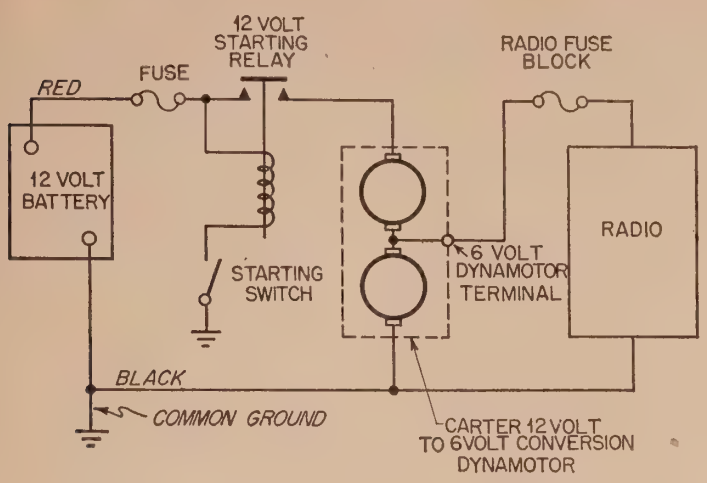


Fig. 2-5-B. Installation diagram of the Carter "Change-a-volt" dynamotor.

The double-pole single-throw relay will turn on both the rig and connect the resistance into the circuit at the same time. Two single-pole automotive type relays may be used if the coils are connected in parallel. A 20 ampere fuse should be put in the resistance line, and the normal fuse in series with the radio equipment should be retained.

The main advantage of this system is the low initial cost. The major disadvantages are its low efficiency, and the fact that a connection must be made to the battery. Also, the battery must be frequently checked to determine if the two sections have become unequally discharged. This resistor system, therefore, should be only used with low power equipment.

Rotary Conversion

A new rotary converter has been recently placed on the market by the *Carter Motor Co.* which will convert a 12-volt supply to 6 volts *(Fig. 2-5-B)*. This *Change-a-volt* dynamotor has two 6-volt commutators in series, and might be best described as a rotary direct current autotransformer. The two 6-volt commutators are connected in series across the 12-volt battery and 6 volts may be taken from the common tap between them *(Fig. 2-5-C)*.

A typical *Change-a-volt* dynamotor will handle 6 volts at 15 amperes on receive, and 6 volts at 45 amperes on transmit. The efficiency of the unit is approximately 65% under either of these conditions. The d.c. output at a load of 15 amperes is 7.3 volts, and drops to 6.0 volts at a load current of 45 amperes. This exceptional regulation is due in part to the very heavy windings in the converter, and to the low rotational speed of the unit.

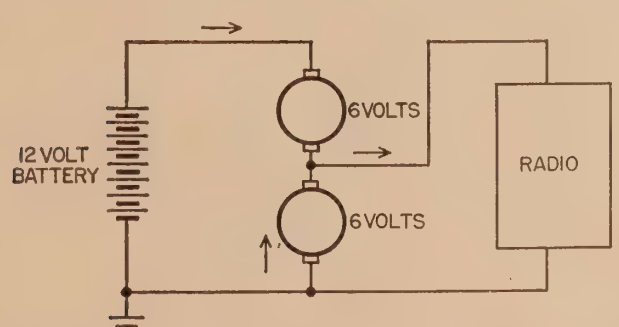


Fig. 2-5-C. Schematic of the "Change-a-volt" dynamotor.

2.6—The PE-103A Dynamotor

The surplus PE-103A dynamotor unit is well suited for use in a medium-power mobile installation. It is a dual input voltage unit, delivering some 90 watts of high voltage power at an average efficiency of 55% from either a 6-volt or 12-volt d.c. primary source. The nominal rating of the PE-103A is 500 volts at 150 milliamperes. For intermittent amateur use, up to 275 milliamperes can safely be drawn for short periods of time. The voltage and current curves for the PE-103A are shown in *Fig. 2-6-A*. The output voltage will vary slightly from the curve shown depending upon the exact value of primary voltage and whether or not the car generator is charging.

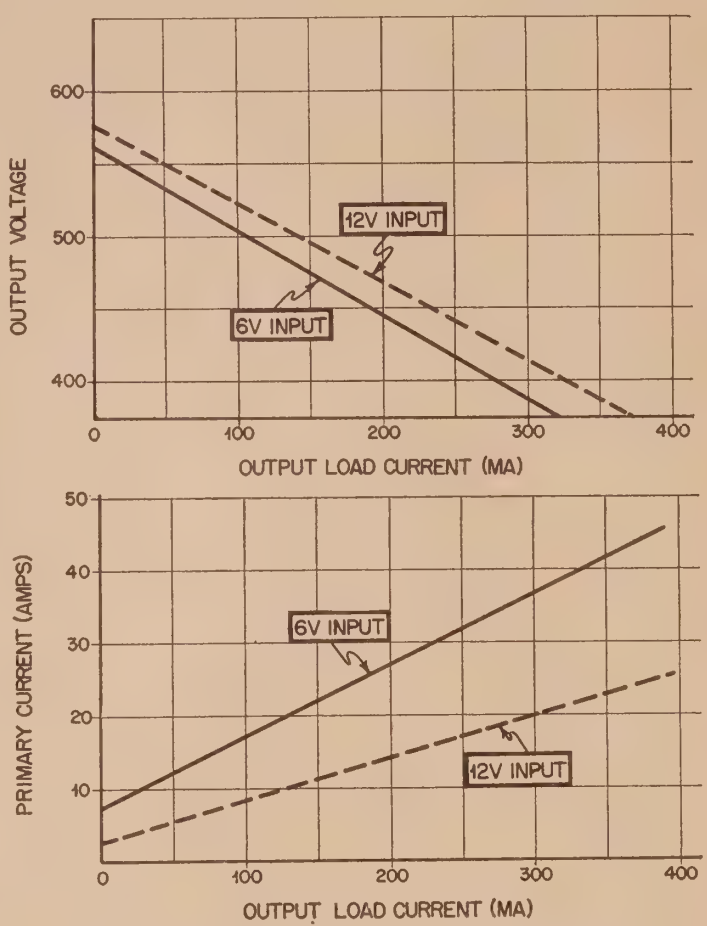


Fig. 2-6-A. These two graphs show the output voltage and primary current of the PE-103A dynamotor as a function of output load current.

The schematic wiring diagram of the complete PE-103A is shown in *Fig. 2-6-B*. Two primary commutators are used, a heavy duty one for 6 volts and a second somewhat lighter one that is added in series with the 6-volt one for operation on 12 volts.

If the PE-103 is to be used only on 6 volts, it is wise to remove the 12-volt brushes to reduce the commutator drag. This will drop the primary current about 1 ampere.

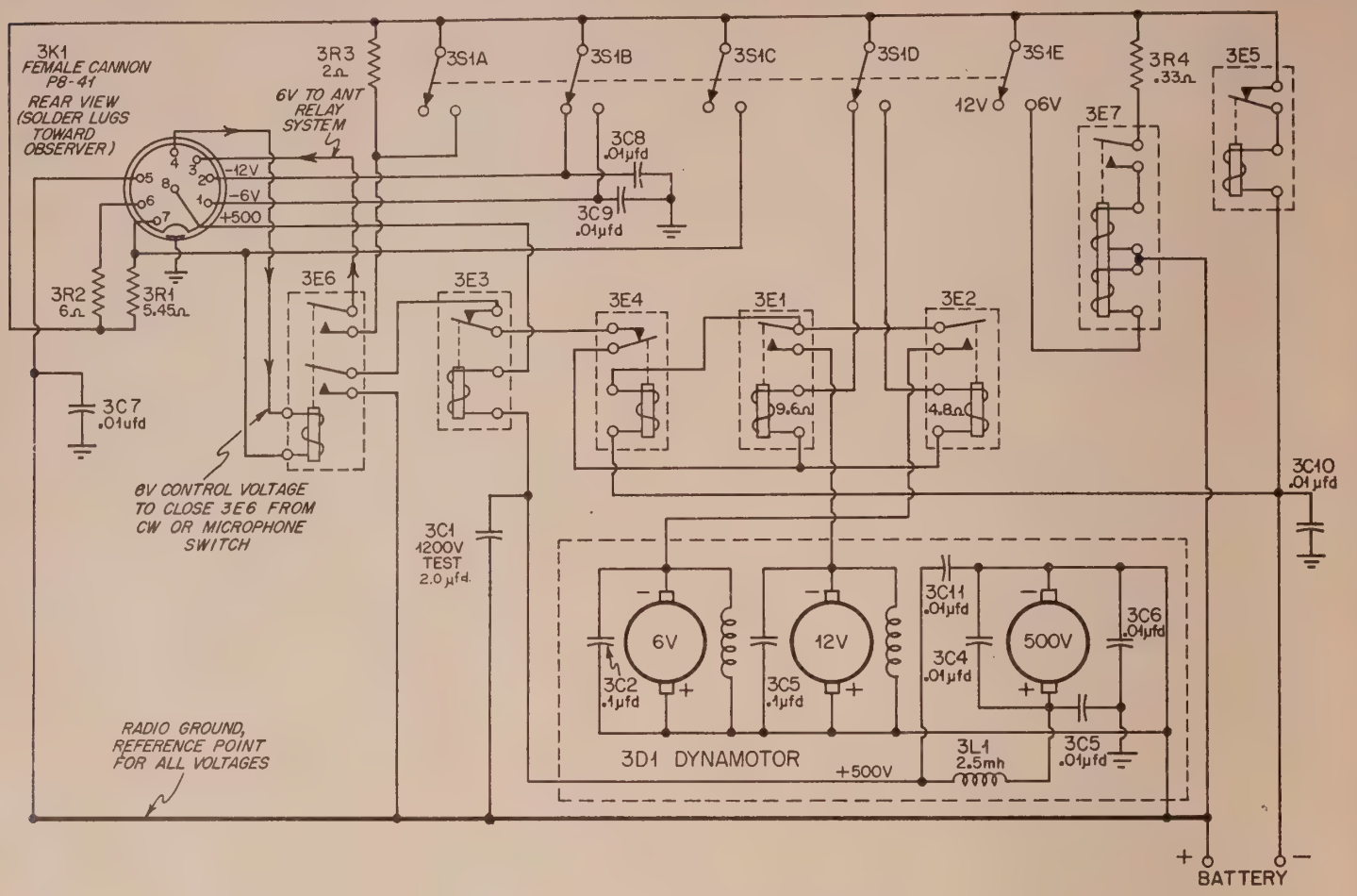


Fig. 2-6-B. Wiring schematic of the PE-103A.

The pin connections to the PE-103A are: (for 6-volt operation)

Plug:
Cannon P8-CG-12S
Pin 1—A minus 6 volts
Pin 2—Not used
Pin 3—A minus 6 volts (on when dynamotor is running)
Pin 4—Control
Pin 5—B—, A plus 6 v.
Pin 6—Not used
Pin 7—A minus 6 volts
Pin 8—B plus 500 v.

For 12-volt operation the pin connections are:

Pin 1—Not used
Pin 2—A minus 12 volts
Pin 3—A minus 6 v. (on when dynamotor is running)
Pin 4—Control
Pin 5—B—, A plus 12 v.
Pin 6—Not used
Pin 7—Not used
Pin 8—B plus 500 v.

For either 6 or 12-volt operation connecting *pin 4* to *pin 5* will start the dynamotor.

Referring to *Fig. 2-6-C:* The 6v 12v switch *3S1* is on 6 volts, the circuit breakers are closed and the relays are not energized. Connection to the battery is made through two heavy cables and connections between the PE-103A and the equipment is made through an 8-conductor receptacle mounted on the PE-103A control Box. *(Cannon P-8-41)*

When the control circuit (pin 4) is connected to the B minus (pin 5) relay *3E6* is energized. One pair of contacts on this relay energizes the 6-volt starting relay *3E2* through the *3E3* and *3E4* circuit breakers. These are high and low-voltage circuit breakers respectively. If any of these circuit breakers open the dynamotor will stop. The high-voltage breaker will open at about 220 milliamperes, and the 6-volt breaker will open at 40 amperes primary current. If a 12-volt battery is accidentally connected to a PE-103A set for 6 volts, relay *3E7* will close and open breaker *3E5* disconnecting the battery and protecting the dynamotor. *Pin 3* supplies 6 volts to operate an external antenna relay.*

Condensers *3C9* and *3C10* bypass r-f currents to ground.

Condenser *3C2* is a ripple filter for the 6-volt armature.

Condensers *3C1, 3C4, 3C5, 3C6, 3C11* and choke *3L1* constitute a hash ripple filter for the high voltage armature.

For 12-volt operation *(See Fig. 2-6-D),* relay *3E1* is the 12-volt starting relay. Resistor *3R1* drops the 12 volts to 6 volts to operate the control relay *3E6.* Resistor *3R3* drops the 12 volts to 6 volts to operate an external antenna relay. *Pins 6* and *7* provide a dropping network to supply 6 volts to the filaments of certain tubes in the SCR-284 radio set and are of no use in amateur operations with the dynamotor.

Modification of the PE 103A

Two slight modifications are desirable for amateur use of the PE-103A:

1. If no 12-volt operation is intended the 12-volt brushes should be removed. Also, relay *3E7* should be removed from the circuit by disconnecting the heavy relay lead terminating at the "plus" primary terminal. This will prevent a constant 15 milliampere

* Units having serial numbers below #4711 have no high voltage circuit breaker and the B plus is connected to pin 3 instead of pin 8.

drain from the automobile battery if the circuit breakers are left on.

2. The high voltage circuit breaker *3E3* is very sensitive and is liable to cut out on a heavy modulation peak. Shunt a 47-ohm 1-watt resistor across the breaker coil. The breaker will now cut out at about 260 mills.
3. There are three available pins for the filament return: *pins 1, 3* and *7*. *Pins 1* and *7* are in parallel and are in series with breaker *3E5* which will open at a load of 7.5 amperes. *Pin 3* is also in series with *3E5* and also in series with *3E6* the control relay. This pin may be used for the filament circuit of instant heating tubes since the filament voltage comes on at the same time as the high voltage. In all cases, *pin 5* is the filament return pin. When 12-volt tubes or relays are used for 12-volt operation resistor *3R3* must be shorted out.
4. When the PE-103A is used in an automobile where the negative of the battery is grounded to the car, the high-voltage commutator should be switched. The wires on the high voltage positive brush should be removed and connected to the negative brush. The negative brush wires should be connected to the positive brush. The positive battery cable then goes to the negative of the battery terminal, and the negative cable is connected to the positive battery circuit.

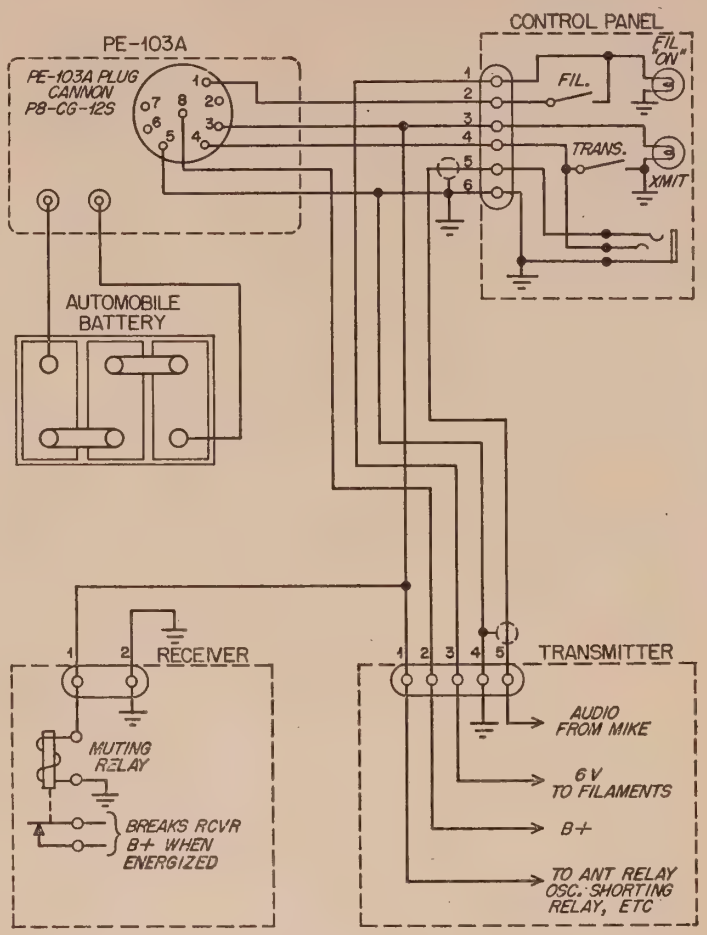


Fig. 2-6-E. This is a suggested control circuit to be used in conjunction with the PE-103A.

Starting Current

The starting current of a dynamotor is several

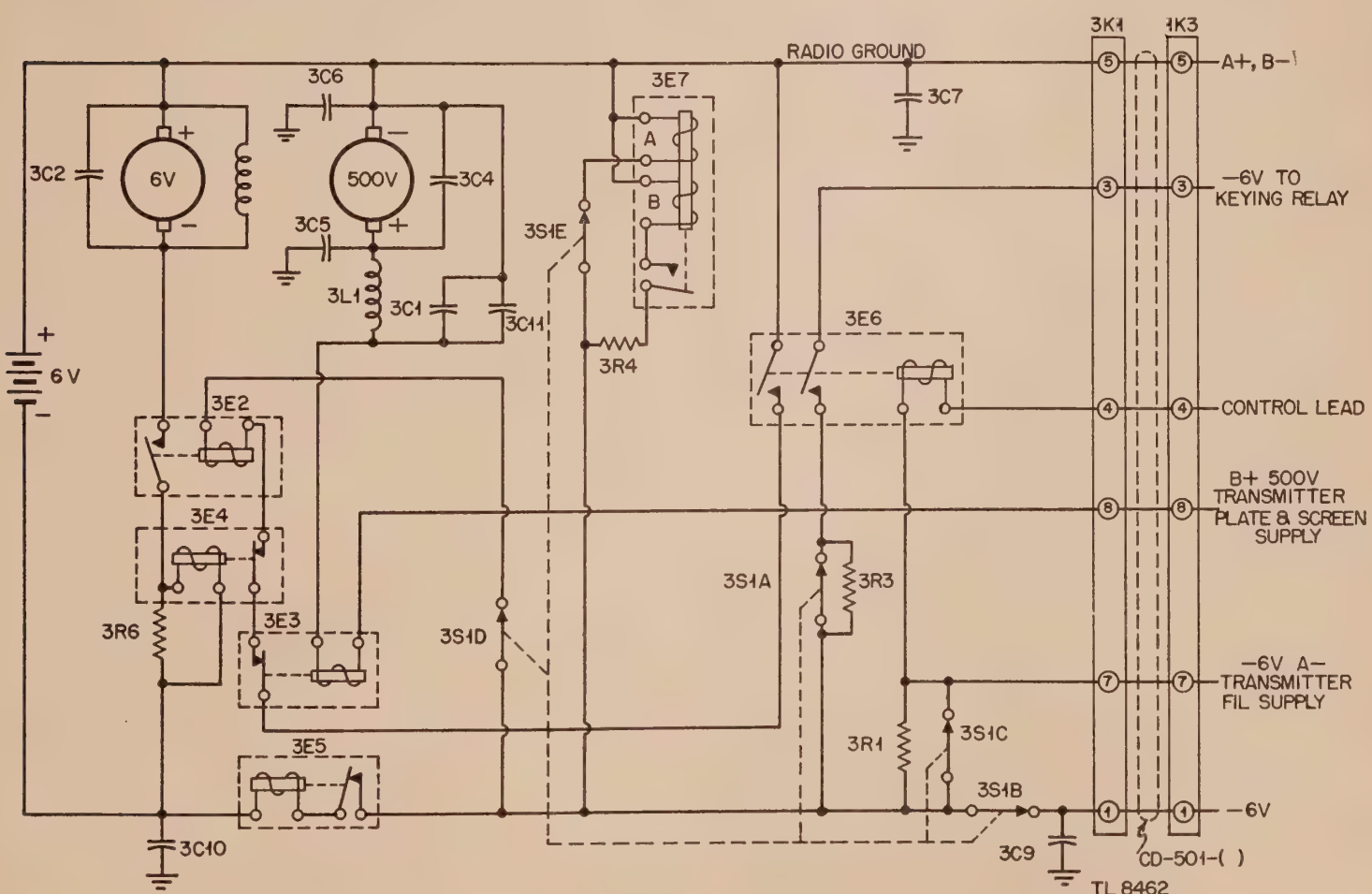


Fig. 2-6-C. Simplified schematic of the PE-103A when set up for 6-volt operation.

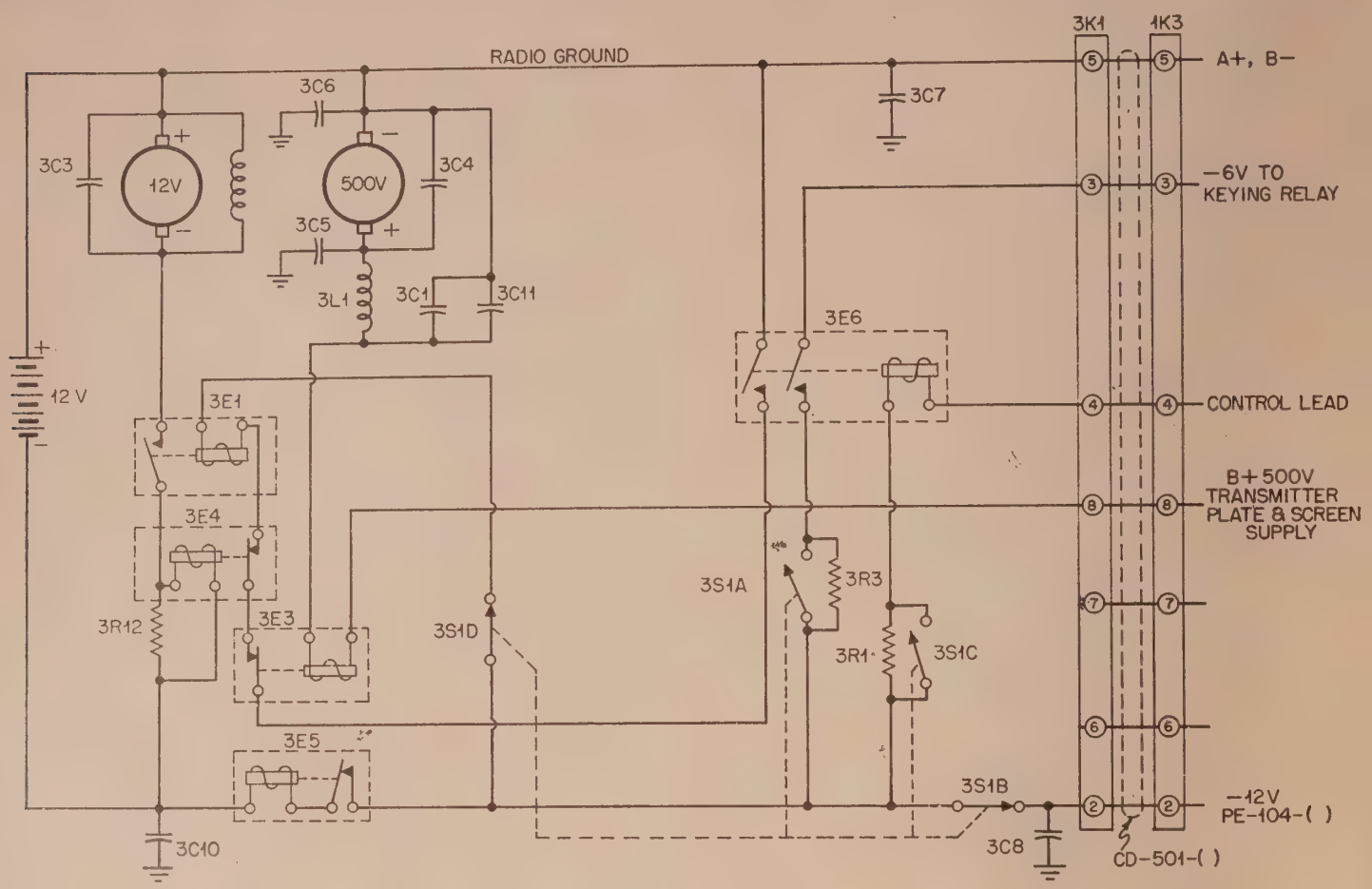


Fig. 2-6-D. PE-103A set for 12-volt operation.

times greater than the full load running current. The PE-103A has a starting current of 150 amperes. This surge is only of a few seconds duration but if it occurs in a rapid sequence such as might be encountered in break-in phone operation it will be sufficient to cause quite a heating loss in the power leads and the dynamotor itself.

A ground lead should run directly from the battery to the dynamotor. Never use the chassis of the car for a power return.

Control Circuits for the PE-103A

The PE-103A dynamotor has complete control wiring in the base in addition to low-voltage, high-voltage and filament circuit breakers. *Figure 2-6-E* shows a suitable transmitter control circuit that makes effective use of the inherent control wiring of the PE-103A. A small control panel containing a "Filament ON" switch and pilot lamp, a "Transmit" switch and pilot lamp, and a microphone jack will activate the complete mobile installation. When the "Filament ON" switch is closed the transmitter filaments will light and the warning pilot lamp will come on. When either the "Transmit" switch is closed or the microphone control button pressed the dynamotor starts and high voltage is applied to the transmitter and the "Transmit" light goes on. In addition, the antenna relay operates to apply the antenna to the transmitter and the receiver is muted by breaking its high voltage. *(See Fig. 3-1-E)* When operation of the equipment is completed, the "Filament ON" switch is turned off. When the car is not in use, circuit breaker *3E4* on the PE-103A dynamotor should be opened as a safety measure.

It is suggested that a spare set of contacts on the antenna relay be used to break the high voltage to the transmitter oscillator. The output of the dynamotor does not drop to zero the moment the primary power is removed and there is a space of time during which the transmitter oscillator still runs while the receiver is in operation, thus blocking the receiver for a short interval.

2.7—A High Power Mobile Supply

A primary power drain of 100 watts is about the maximum that can be obtained from the standard battery systems on present day cars. This limits the power input to the transmitter to the region of 60-70 watts. A means of overcoming this problem is to belt drive a high voltage dynamotor from the car engine. Either a surplus BD-77 (12-volt dynamotor) or a PE-73 (24-volt dynamotor) may be used for this purpose *(Figure 2-7-A)*. These dynamotors provide a secondary voltage of 1000 volts at 350 milliamperes when run from the correct primary source. When these dynamotors are used as generators the input winding is carrying much lower than normal current and the ouput load can be increased to draw 500 milliamperes without overheating. In actual use these generators has been run intermittently for several hours at 1100 volts and 500 milliamperes without excessive heating. This will allow a power input

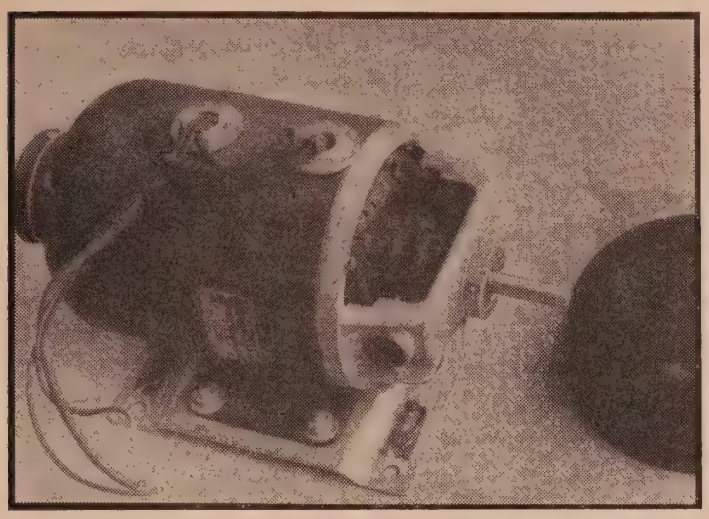


Fig. 2-7-A. A war surplus BD-77 dynamotor was stripped down and a pulley mounted with the aid of a shaft extension on the end that provides correct rotation.

to the final stage of the mobile transmitter of some 250-300 watts. The 811, 4-65A, 35T, and 4X-150A are a few of the tubes that will work well with this power supply.

Dynamotor Modifications

The only constructional work necessary is to extend the shaft of the dynamotor in order to mount a pulley on it, and to mount an additional pulley next to the pulley of the present car generator *(Figure 2-7-B)*.

First remove the covers and end bells from the frame of the dynamotor. Next, remove the brushes being careful to mark each brush so that it can be put back in exactly the same position. It should now be possible to remove the armature from the dynamotor. After removing the armature from the frame the next step is to pull the ball bearings prior to doing some lathe work on the shaft. If a gear puller is available, the job is easy; otherwise hold the bearings in a vise (protect the bearings with a piece of soft sheet copper) and drive out the shaft with a piece of brass rod and a hammer. Be careful not to bend the sheet metal cover plates on the ball bearings. Next, the 0.500-inch shaft should be extended on one end for about 2½ inches. This can be done as shown in *Fig. 2-7-C*.

Which end of the shaft that is to be extended depends upon the direction of engine rotation. This dynamotor was used on a '49 Chevrolet engine which rotates clockwise (looking from the front of the car towards the engine). In this case the shaft extension was put on the end carrying the low-voltage commutators.

Next, drill a 9/16-inch hole to pass the extended shaft through the adjusting nuts and the end covers. The last step is to disconnect the field lead going to the ungrounded terminal of the low-voltage armature winding. This lead should be extended to the outside of the case and will be used in conjunction with a voltage regulator.

The generator may now be reassembled and a 3-inch pulley put on the extended shaft. These ½-inch shaft pulleys can be obtained from several national mail order houses. Next, a 4-inch pulley is fastened to the car generator pulley by means of ¼-inch screws and 1-inch spacers. The length of the spacers will vary depending upon the type of generator used.

Figure 2-7-B shows how the generator was mounted on a '49 Chevrolet. Obviously this type of mounting may not work on other type cars but it will provide a general idea of how to attack the problem. At the left, near the bottom of the photograph is shown the adjusting nut and screw which move in a slot to take up the wear on the "V" belt. The FT-107B frame came with the dynamotor. The dynamotor is held to the frame by snap action catches which should be wired in place to prevent engine vibration from working them loose. In the installation, lock washers should be used wherever possible.

Voltage Regulation

Without a voltage regulator of some sort the voltage would vary considerably with engine speed. The regulator circuit used is shown in *Fig. 2-7-D*. The relay is operated by the "Transmit" relay located at the transmitter. A 50-ohm 10-watt resistor is shunted across the contacts of the regulation relay to prevent burning of the contacts. The carbon pile regulator is a 14-volt type available on the surplus market. It starts to level off the voltage at about 900 volts d.c. at 35 m.p.h.. At 65 m.p.h. the output is about 1100 volts. If much city driving is to be done, an improvement in voltage regulation could be obtained by rewinding the generator field coil to work on 6 volts. (For a voltage reduction of one-half the wire size should be decreased three number sizes.) The field could then be supplied from the car battery which would result in better regulation than when the field is self-excited as described above. Also, for city driving it probably would be desirable to increase the pully ratio to 5:3 to give more voltage at lower car speeds.

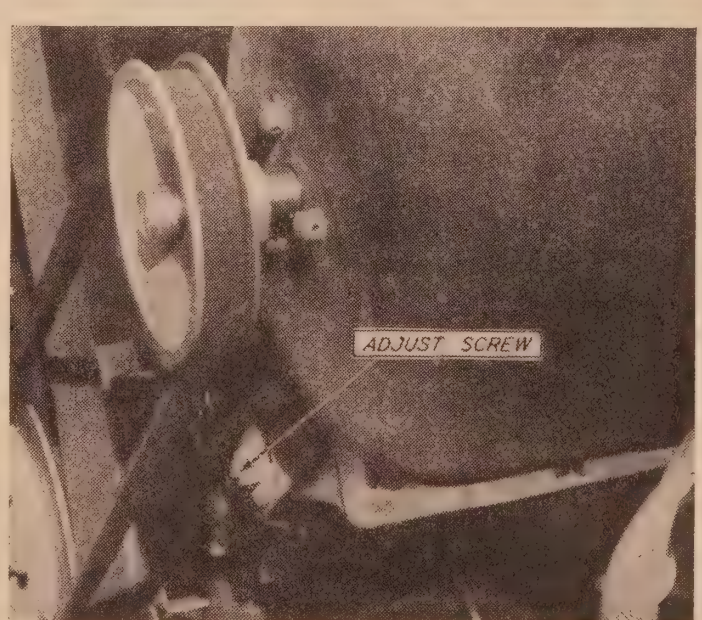


Fig. 2-7-B. The BD-77 as mounted in a 1949 Chevrolet.

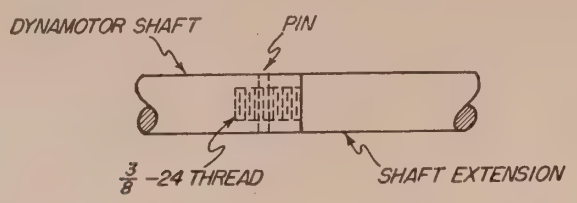


Fig. 2-7-C. The BD-77 dynamotor shaft is drilled and tapped to receive a 3/8-24 thread. The extension shaft is threaded and the two are firmly screwed together, a 1/16-inch hole is drilled through the joint and a steel pin is driven into the hole.

No reduction in gas mileage or car power has been noticed with the addition of the generator system.

Notes on the PE-73C

The PE-73C dynamotor is the 24-volt counterpart of the BD-77. It, too, may be modified as above to work as a generator. A 24-volt regulator instead of a 12-volt regulator should be used. There is no difference in operation between the two different dynamotors.

2.8—Modification of the PE-101C Dynamotor for Amateur Use

The PE-101C dynamotor is a multiple winding dynamotor shown in *Fig. 2-8-A* in its original form. It has a large right-angle Cannon plug on the top, and a sealed-in-oil 800:1 gear reduction box on one end. The dynamotor was designed to operate on either 13 or 26 volts d.c. by placing the primary windings in either a parallel or series connection. The ratings given on the nameplate have no bearing as to the actual ratings of the dynamotor, they merely indicate the ratings of the unit as used as part of the BC-645 equipment for which the dynamotor was originally employed.

Figure 2-8-B is a schematic diagram of the windings in the unit and their electrical relationship to each other. The primary wires are completely separate so there is no problem of positive or negative grounds. Two 400-volt windings are connected in series internally within the unit, and one end of this winding is grounded. The two windings are identical as to wire size and are both capable of carrying a load, from each tap, of some 125 milliamperes.

The dynamotor will work well on either 6 volts or 12 volts and delivers, after modification, the following simultaneous outputs:

12 volts input	6 volts input
610 volts at 150 ma.	300 volts at 90 ma.
325 volts at 125 ma.	160 volts at 110 ma.

During a protracted run at the above loads the dynamotor did not get warm, indicating that these loads are not the upper power limit of the unit. The limiting factor of dynamotor life is the heat generated in the unit by friction and loss heating. If the dynamotor runs cool, it is running within ratings.

Conversion of the Dynamotor

Remove the safety wires holding the end bells. Loosen, but do not remove the eight end bolts. Open the cover on the long end and remove the four countersunk bolts which are visible. Slide both end bells off. With a pair of pliers remove the pin from the end of the armature shaft which connects to the gear box drive. With a long screwdriver reach in through the open side of the gear reduction box mounting bracket and remove the four bolts holding the gear box in place. Remove the gear box.

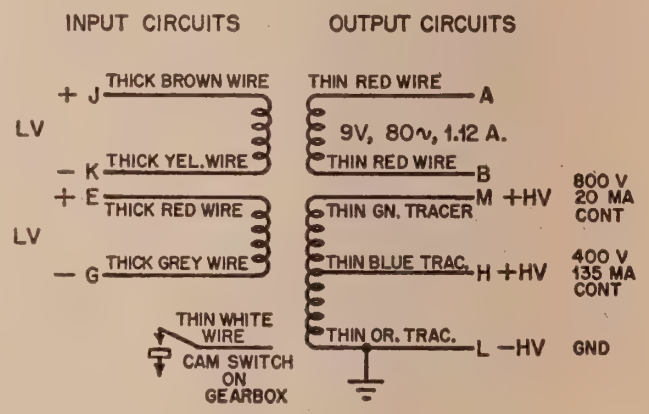


Fig. 2-8-B. Schematic of the PE-101-C windings with their rating and color coding.

Take off the snap ring on the goose-neck plug and remove the top. Clip the wires close to the disc and tag them if the color code is not legible. Remove the entire top assembly.

Now, turn the dynamotor over and remove the mounting plate. Replace the bolts in their original holes, leaving the base off. With a sharp ½-inch drill carefully drill two holes in the base so that when the wires which are sticking out of the top of the dynamotor are fed through these holes the base will fit snugly up against the frame of the unit in its original position, but on the side from which the goose-neck was removed. The wires will now protrude through the holes that you have drilled in the base, which may be bolted in this position by enlarging the base holes in the proper direction so that they match the top-side holes. This

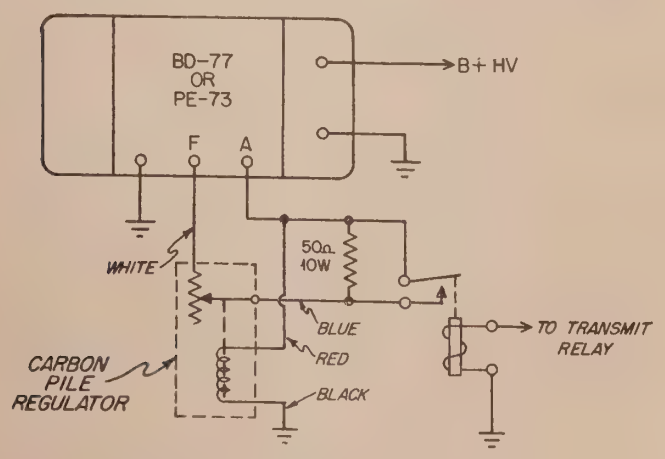


Fig. 2-7-D. This is the regulator circuit used by W6WI in conjunction with a modified BD-77 generator. The carbon pile regulator can be a Bendix #956 12-volt model.

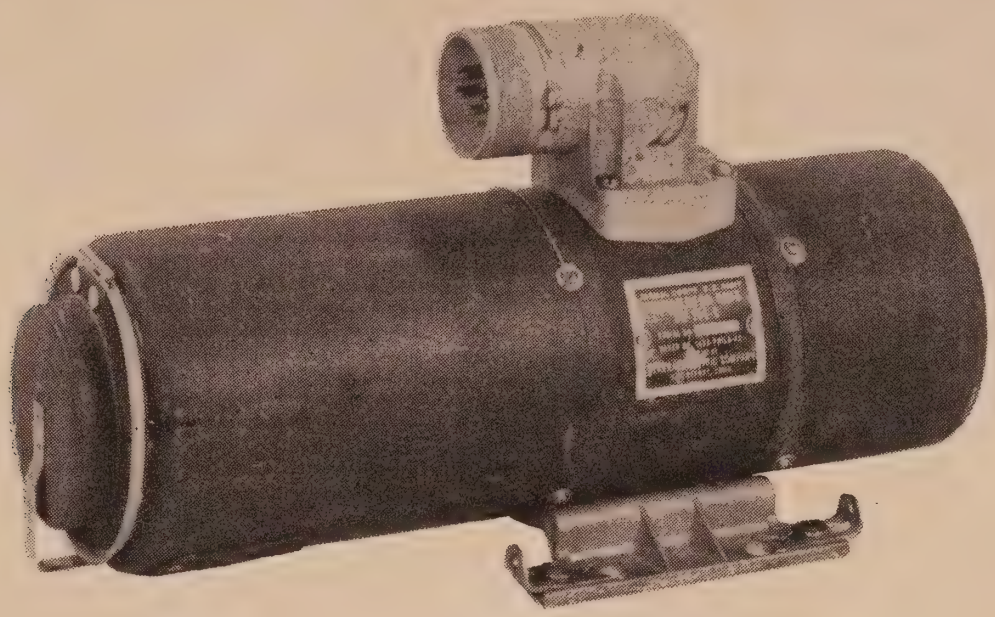


Fig. 2-8-A. The PE-101-C dynamotor as purchased in war surplus.

may be done with the side of a drill or a small "rat-tail" file. The bolts which held the gooseneck should now be shortened a bit so that they will not interfere with the field winding inside the dynamotor, and then used to bolt the base to the dynamotor.

Pull out the thin white wire marked *cam switch* and discard it. Remove the a-c brushes and their wires.

The long end bell should be cut down to reduce the overall size of the dynamotor since the reduction gear is removed. The bell is somewhat fragile, so care must be taken in this operation. There are two suggested ways:

1. Clamp the bell end in a vise and saw off the unwanted section with a hacksaw. Square the cut end on a sheet of coarse emery paper. Allow ½ inch extra to the length of the end bell to compensate for errors in cutting.
2. Chuck the end bell in a lathe and use a sharp cut-off tool to remove the unwanted section. A very slow cut must be made or the bell will collapse.

Replace the end bells on the dynamotor. This completes the conversion on the dynamotor. To make a neat job mount the unit on a 3″x5″x12″ chassis in which you can place the relays, filters and wiring.

Control Circuit

For either six-volt or twelve-volt operation the low voltage windings on the dynamotor are placed in parallel. The brown and red leads are connected together, as well as the yellow and grey.

Figure 2-8-C shows the complete control circuit for use with a 6-volt automotive system. An extra battery is required for 12-volt PE-101-C input. This circuit places the two batteries in parallel for charging and in series for transmitting.

Relay *Ry2* switches the batteries from series to parallel as the occasion demands. Under normal conditions the batteries are in parallel so that the auxiliary battery will be kept fully charged. When the press-to-talk button is depressed for transmitting, the relay operates and the auxiliary battery is placed in series with the regular battery and 12 volts is applied to the dynamotor. In the event low-power operation

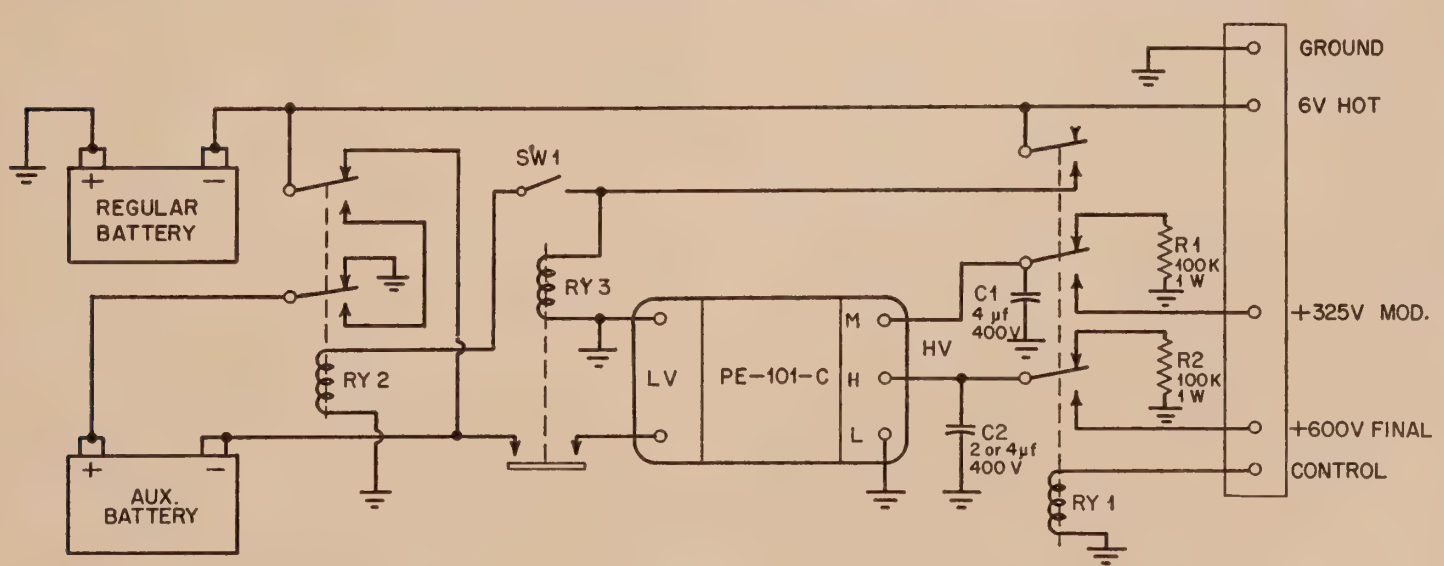
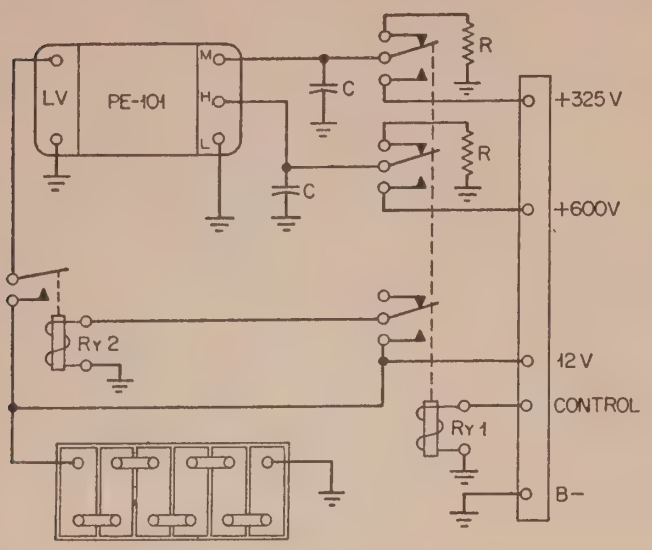


Fig. 2-8-C. This is the control circuit to be used for 6-volt automotive system and a separate battery to obtain 12 volts.



C = 4 μfd, 600V OIL CONDENSER
R = 100,000 OHM, 1 WATT RESISTOR
Ry1 = 12 VOLT CONTROL RELAY, 3POLE DOUBLE THROW
Ry2 = 12 VOLT HEAVY DUTY CONTACTOR RELAY

Fig. 2-8-D. This circuit enables the PE-101-C to be used directly in the new automobiles with the 12-volt electrical system.

of the transmitter is desired for initial tune-up, switch *Sw1* is opened which disconnects the battery switching relay and applies only 6 volts to the dynamotor.

In actual practice, if the auxiliary battery is connected into the system with fairly long cables (as would be the case if the battery is mounted in the rear of the car) the cables will introduce enough resistance into the circuit to throw almost all the starting load of the car starter on to the original car battery which is connected to the starting motor by very short, heavy leads. Thus the starter current does not flow through the contacts of *Ry2*.

It is suggested that the 400-volt tap be used to run the modulator and oscillator section of the transmitter and the 600-volt tap be used on the final amplifier stage.

For cars with a 12-volt ignition system, the circuit of *Figure 2-8-D* is recommended.

2.9—Control Circuits

The design of mobile transmitting equipment must follow a slightly different pattern than that of the usual fixed location equipment. Unless the mobile set is mounted directly in front of the operator (a difficult thing to do in an auto) some sort of remote control arrangement must be used, with the transmitter located in a more reasonably acceptable spot. The transmitter may be located in the trunk, on the engine firewall, in the engine compartment, or even in the glove compartment. The exact location will depend upon the size of the equipment and the tolerance of the other users of the car.

The use of a remote control panel located near the operator will allow correct operation of the equipment when it is located at a distance from the operator. *Figure 2-9-A* illustrates a simple control panel for a typical mobile installation. Heavy wires *A* and *B* are the primary power leads and run directly from the battery to the dynamotor (or vibrator supply) broken only by a protecting fuse and control relay. If the transmitting equipment and dynamotor are located in the trunk compartment of the car, these leads may be run under the frame of the car, securely taped to a frame girder along the way. They are brought into the trunk compartment by means of a small hole drilled in the floor of the compartment. These leads carry considerable current and should be made of heavy wire. They should be well insulated from the car frame and from each other. Care should be taken to see that they do not chafe against sharp edges of the car frame.

The protective fuse should be located near the battery. For current drains of 30 amperes or less, an ordinary house fuse mounted in a porcelain socket will serve the purpose. It should be in series with the ungrounded battery lead.

The control box is connected to the dynamotor by *leads 1, 2, 3, 4* and *5*. *Leads 1* and *2* carry the filament current of the transmitter and the current drawn by relay coil *Ry1*. This will usually amount to several amperes, so a suitable choice of wire should be made. *Lead 3* carries only relay coil current, so it may be made of No. 18 insulated wire. *Lead 4* is the microphone lead and must be made of shielded wire. The shield should be tightly woven and securely grounded to the car at both ends. *Lead 5* is the control box ground return lead.

Four leads run from the dynamotor to the transmitter, *numbers 6, 7, 8 and 9*. *Numbers 6 and 9* are filament leads and should be made of sufficiently heavy wire to carry the required load without appreciable voltage drop. *Leads 7 and 8* carry relatively small current and may be made of No. 18 insulated wire. *Lead 9* is the ground return wire. All leads to the control box should pass through a suitable plug and socket so that the control box or the cables may

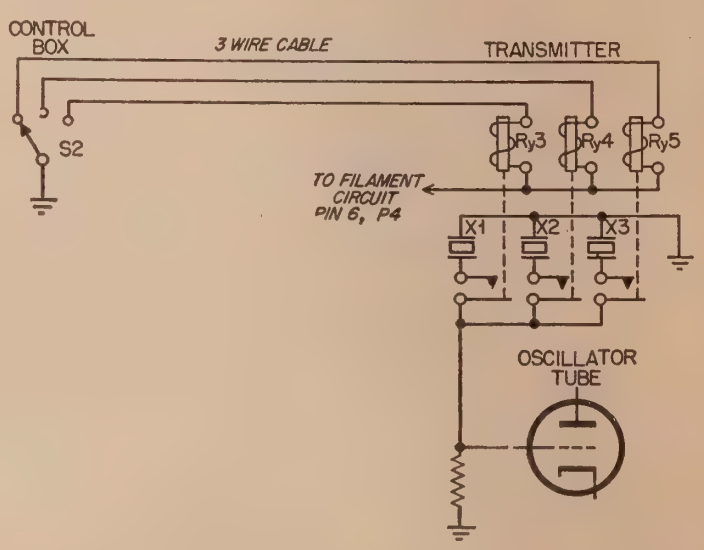


Fig. 2-9-B. This control circuit permits remote crystal selection.

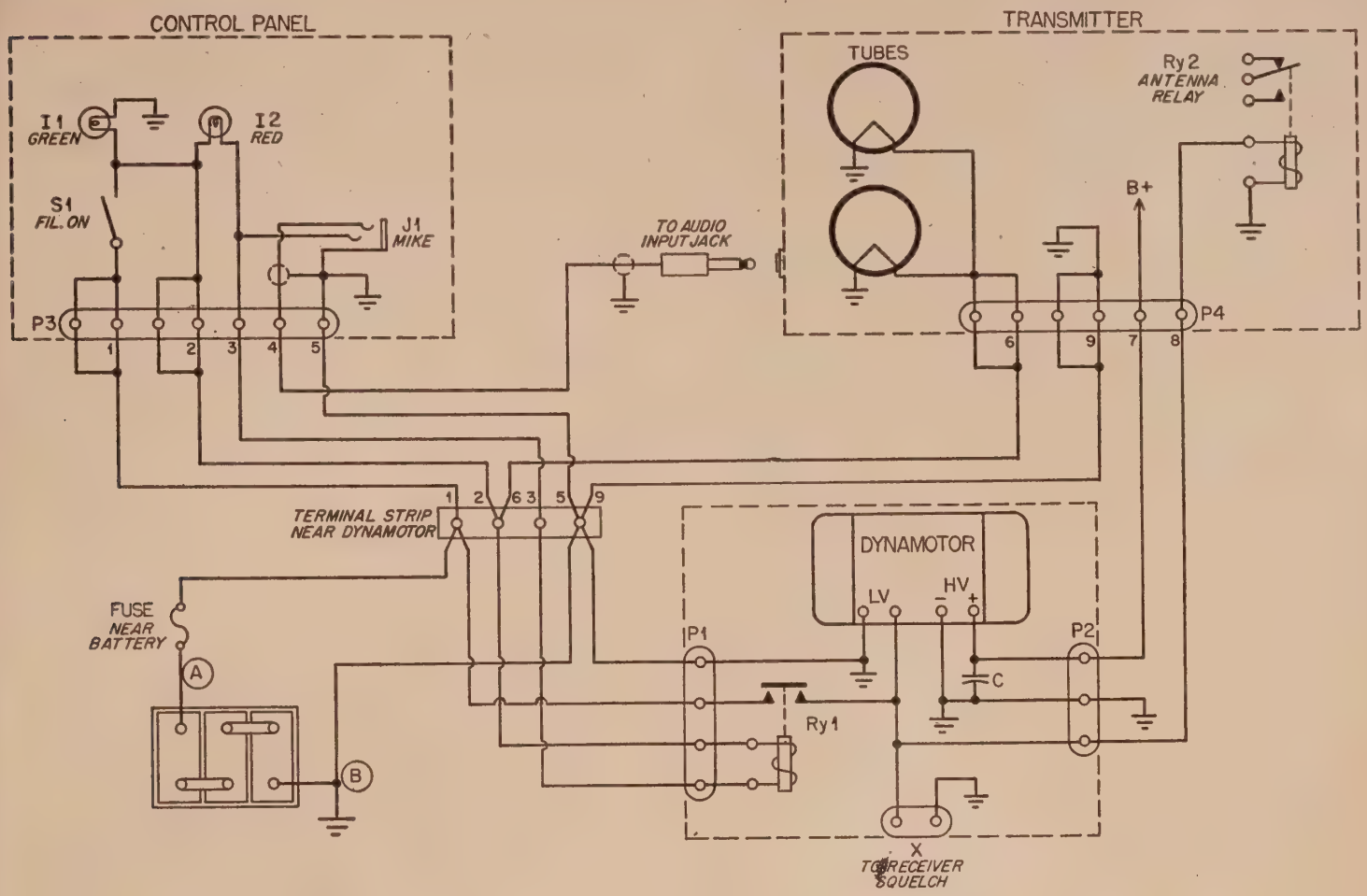


Fig. 2-9-A. Wiring schematic of a simple control panel circuit for mobile use.

I1, I2—Pilot light assembly Drake #10.
P1—Plug, S-404CCT; socket P-404SB (Cinch-Jones)
P2—Plug, S-304CCT; socket P-304AB (Cinch-Jones)
P3—Plug, S-308CCT; socket P-308FP (Cinch-Jones)
P4—Plug, S-306CCT; socket P-306FP (Cinch-Jones)
Ry1—relay, starting, 6v. coil, Advance type 951C.
Ry2—relay, antenna, 6v. coil, Advance series 2000.
J1—3-circuit jack, ICA #1872.
S1—Power switch, ICA #1281.
S2—Switch, single-pole, triple-throw, Centralab #1461.

be readily removable for servicing or circuit changes. The plug may be mounted on the back of the control box. Two adjacent pins of the plug should be paralleled to carry the current flowing in *leads 1and 2.*

The control panel contains a "Filament ON" switch and pilot lamp. When this switch is turned on the filament circuit is closed and both the tubes and the filament circuit pilot lamp are energized. The pilot lamp should be green in color, to signify that the low potential circuits are connected. At the same time, one side of relay coil *Ry1* is connected to the hot 6-volt lead. When it is desired to put the transmitter on the air, *wire 3* is connected to *wire 5* (ground) by means of a "press-to-talk" microphone, through the jack circuit on the control box. When *wire 3* is grounded the red "Transmit" light goes on, the opposite side of relay coil *Ry1* is grounded and relay *Ry1* closes. The dynamotor starts, and in the transmitter, antenna relay *Ry2* is energized, disconnecting the antenna from the receiver and applying it to the transmitter. An additional lead may be taken off at point *X* to energize the squelch relay located in the receiver. (See *Fig. 3-1-E, Chapter 3)*

Elaborating upon this basic design, additional control equipment and circuits may be added to the basic control box. *Figure 2-9-B* illustrates a frequency shifting switch that allows the selection of several crystals. *Figure 2-9-C* shows the addition of a milliammeter to read the dynamotor secondary current drain. An additional push button type switch may be added between *wires 3 and 5* as a separate "Transmit" switch for use when the microphone circuit is not required. The standard push-to-talk microphone connections are shown in *Figure 2-9-D.*

Control Circuit Components

The choice of components for high amperage control circuits is very important. Many times, the eager mobile enthusiast has thrown the control switch to start the dynamotor in his new mobile installation, only to find his 6-volt battery supply has dwindled to 3 volts at the dynamotor terminals. The d-c resistance of all control circuit components should be carefully examined and only those components with the lowest internal resistance should be chosen. For example, when a current of 50 amperes

flows through a circuit containing a line resistance of only 0.06 ohm, a drop of 3 volts will occur in the line.

Wire

Figure 2-9-E illustrates the resistance values of various lengths of standard gauge copper wire. If the total lead length and wire size are known, the resistance of the wire may easily be found.

Plugs and Switches

The resistance of plugs and switches cannot be graphed in the above manner as the resistance of plugs and switches varies widely, even among the same models made by the same manufacturer. It may be stated, however, that the greater the friction that exists between the two contacting parts, the lower will be the contact resistance. The following table gives some representative contact resistances of certain types of plugs and switches as measured on a Kelvin bridge:

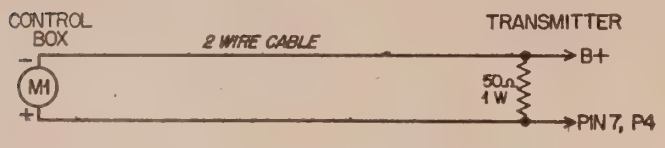


Fig. 2-9-C. There should be some method of observing the dynamotor secondary current drain. This idea can be added to the control circuit shown in Figure 2-8-A.

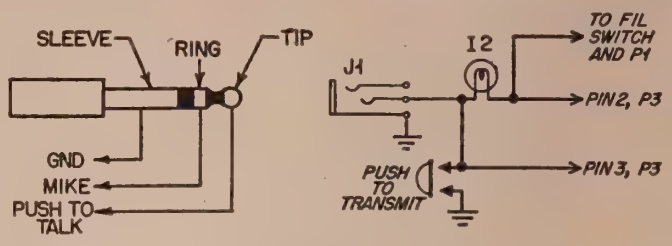


Fig. 2-9-D. Occasionally it is necessary to put the carrier on the air for a few seconds without modulation. The push-to-talk button shown in the right-hand schematic is useful.

Item	Contact Resistance
Jones plug & socket (P-2408)	0.003 ohm
5 prong tube socket & plug	0.05 ohm
Small 3 amp. toggle switch (s.p.s.t.)	0.01 ohm
Large heavy duty toggle switch. (C-H No. ST52-N)	0.003 ohm
"Unimax" snap switch	0.005 ohm

The contact resistance of the tube socket and matching plug varied widely depending upon the frictional fit of the prongs of the plug in the socket. The resistance of the 3-ampere toggle switch increased sharply after a few hours use breaking a current of 10 amperes. This was probably due to oxidation of the contacts.

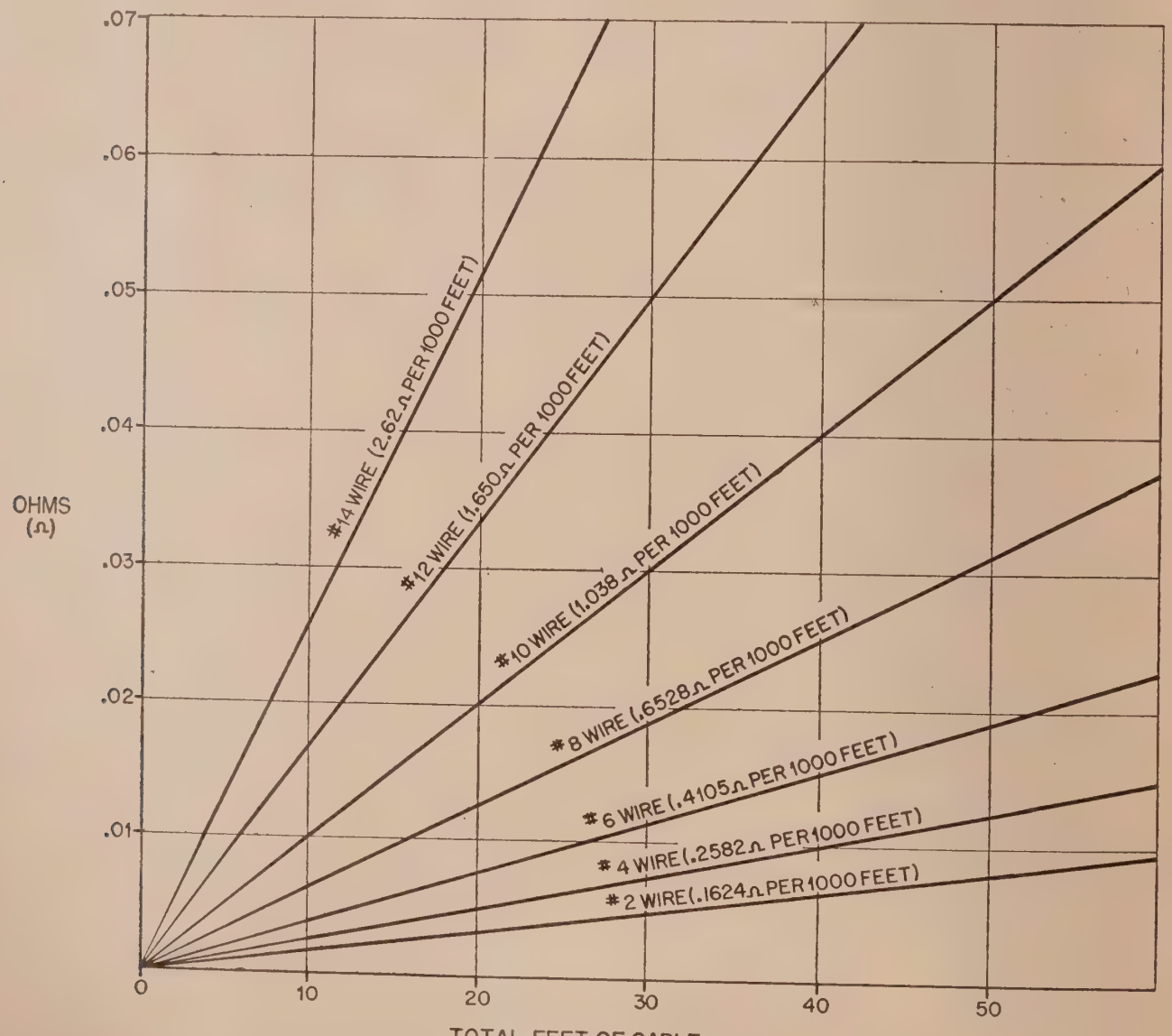


Fig. 2-9-E. Resistance values for various B&S wire sizes.

The plugs and switches designed for heavy currents had sufficiently low resistance to be completely reliable in heavy current circuits.

Relays

Relay contact resistance is a highly variable factor, more so than that of the plugs and switches. In general, a good relay for mobile service should have large, self-wiping contacts, a heavy return spring and a coil that draws at least two watts at 6 volts. The heavy duty coil will insure good contact pressure and a low resistance contact. It is important to keep the relay contacts clean, especially in industrial areas where a silver sulphide compound can easily form on the contact surfaces and increase the contact resistance many times.

A heavy-duty relay that is easily obtainable is the horn relay used in all makes of cars. It is stocked by automotive distributors and may be purchased for under two dollars. It is well suited for making and breaking heavy currents.

2.10—Safety in Mobile Operation

It goes without saying that no amateur operating a mobile station wants to be involved in an automobile accident. Certainly an amateur who has an automobile accident while carrying on a mobile QSO has the unenviable job of proving that he was not negligent. Anything, therefore, that can contribute to making mobile operation as convenient and as nearly automatic as possible will be helpful in promoting driving safety while operating.

Analysis of the activities undertaken while carrying on a QSO from a mobile station revelas that they include the following:

A. While listening—
   1. Tuning the receiver or converter
   2. Adjusting volume

B. While transmitting—
   1. Speaking into the microphone
   2. Holding the microphone
   3. Turning the transmitter on and off
   4. Reducing receiver volume below the point of feedback

The activities which take place during listening periods will be least distracting when the receiver and/or converter controls are located as to be readily accessible to the driver so that he can manipulate them by feel. In areas and on bands where a large number of mobile-to-mobile contacts take place, the amount of tuning necessary can be minimized if all mobile units operate on the same frequency. Likewise, some converters may be so constructed that often-used frequencies, such as net frequencies, can be set up on a push-button of the car radio. This is true of converters in which the local oscillator is crystal-controlled and the output of the converter is a broadband transformer.

Generally, a given setting of the volume control will suffice for a given set of driving conditions and receiving conditions, and with effective automatic volume control of the receiver, relatively little manipulation of the manual volume control during reception is required once communication is established. It can be concluded from these considerations that the activities associated with receiving do not constitute a serious distraction of the driver's attention where care and forethought are given to the design and installation of the receiving equipment.

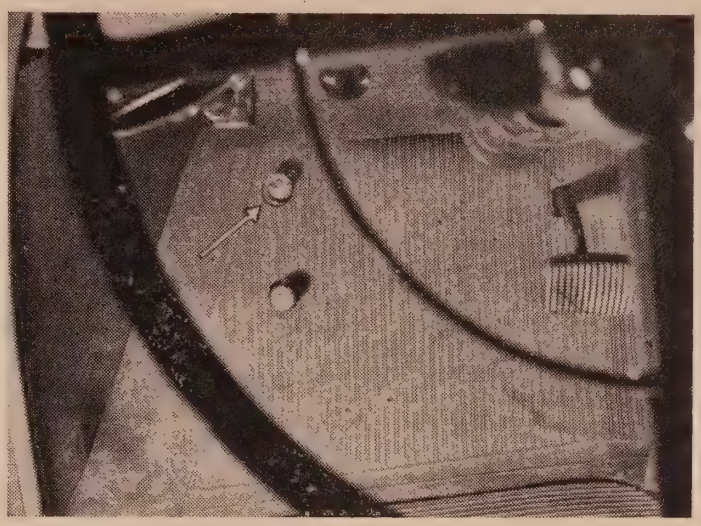


Fig. 2-10-B. Mounting of the foot-operated switch (headlight beam control type) to serve as a transmitter off-on switch at W5CLP.

In the usual installation, it is during the periods of transmitting that most activities take place which serve to distract the attention of the operator/driver. Since carrying on a conversation is so much second nature, the actual talking into the microphone is not a serious distraction. The process of holding the microphone, however, requires the use of one hand which might better be devoted to steering the car, shifting gears, signaling and the like. The "mike hand" may be freed from its task by using some mechanical means of holding the microphone in position. A breastplate mounting for the microphone would serve, but this type of mounting has the disadvantage of requiring that the head be held in one position if the modulation level is to remain reasonably constant. A preferred system is to mount the microphone on some sort of headgear so that it will

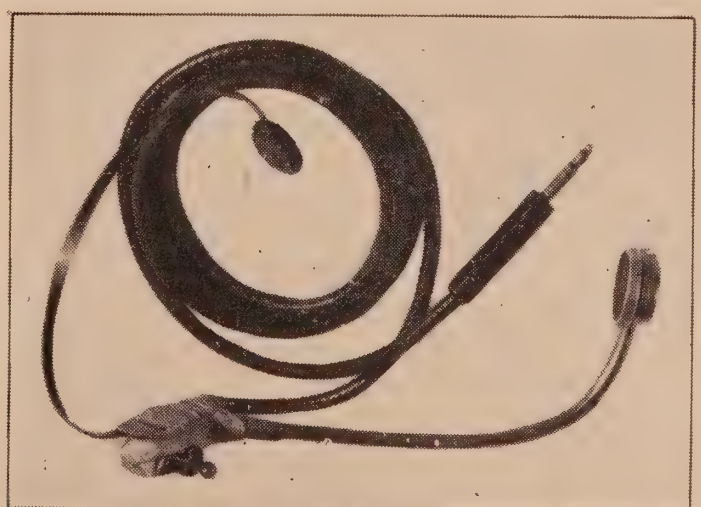
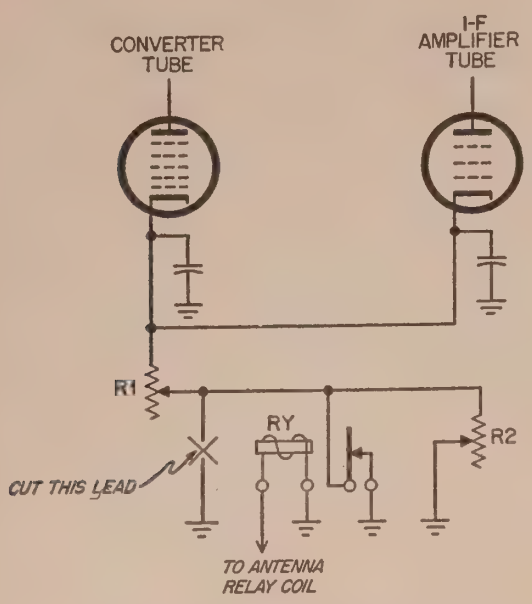


Fig. 2-10-A. Headband mounting of the microphone showing the auxiliary transmit switch.



R1--SENSITIVITY CONTROL OF AUTOMOBILE RADIO. (NOT ALL RECEIVERS ARE EQUIPPED WITH SUCH A CONTROL. IF ONE IS PRESENT, IT SHOULD BE SET FOR MAXIMUM SENSITIVITY.)
R2--10,000 OHM POT TO SERVE AS RF GAIN CONTROL.
R3--6V RELAY WITH NORMALLY CLOSED CONTACTS.

Fig. 2-10-C. Partial circuit diagram of a typical automobile receiver showing the connection of a r-f grain control and relay for reducing receiver sensitivity during the transmission periods.

be properly positioned in front of the lips regardless of the position of the head. A telephone operator's headset is an excellent device for this purpose. A satisfactory substitute can be devised from a single-headphone headband. A device of this nature is shown in *Fig. 2-10-A*. The headband is from a *Brush* single headphone and the microphone is a *Western Electric Type A-1* carbon button. The microphone is mounted on a boom made of quarter-inch nickle-plated brass tubing. This brass tubing is fastened to the headband by means of a bent brass plate which also holds a single-pole single-throw switch. For the comfort of the operator the fitting and the switch are wrapped with adhesive tape so as to provide a smooth surface.

In the usual mobile installation, push-to-talk operation is used, which requires that the control switch be held down during the entire period that a transmission is made. This places an added burden on the hand holding the microphone. It would do little good to mount a microphone on some sort of headgear if it is necessary to use a hand to hold a push-to-talk button; hence, it would be desirable to use some system other than the push-to-talk arrangement. A desirable substitute is a foot-operated switch mounted in such a position that it can be used to turn the transmitter off and on. A step-switch similar to that normally used for lowering the headlight beam in an automobile makes an ideal switch for this purpose. A suitable location for mounting is about five or six inches in front of the usual headlight control switch in the automobile so that the transmitter can be turned on or off with a tap of the left foot *(Fig. 2-10-B)*. During the time that the operator of the mobile equipment is a passenger in the automobile, he may make use of the s.p.s.t. switch mounted on the headband discussed earlier. This switch replaces the usual push-to-talk switch, and is a positive action switch so that it need be touched only when the transmitter is being turned on or off. This leaves the hand, which would normally hold a push-to-talk switch, free for writing and handling maps, reports, etc.

In the usual mobile installation the transmitting antenna is used for receiving, and a relay switches the antenna from the transmitter to the receiver. It has been found that even though this relay opens the coaxial cable leading to the receiver, there is sufficient signal feed-through to cause feedback unless the receiver volume-control setting is reduced or the plate supply of the receiver disabled. Since manual reduction of the volume-control setting requires the use of a hand and thus distracts the attention of the operator, it is desirable to provide some automatic means of reducing receiver gain during periods of transmission. This can be accomplished by providing an auxiliary relay for either disconnecting the plate voltage from some tube in the receiver or in the converter or for reducing the gain of the receiver. It is often convenient for some signal to appear in the receiver output during periods of transmission to provide a means of monitoring the outgoing signal; hence, reduced receiver gain may be preferred to a cut-off receiver. A suitable circuit for reducing receiver gain is shown in *Fig. 2-10-C*. The relay coil is wired in parallel with the coil of the antenna change-over relay. In this circuit, the relay effectively inserts an r-f gain control in the receiver circuit. The adjustment of this gain control may be pre-set so

Fig. 2-10-D. The left-hand backup light has been removed to permit installation of the antenna mount in its place. In this way, the holes drilled on the car body will be covered by reinstalling the light when the automobile is re-sold.

that the volume of the receiver is at the desired value during periods of transmission. Once set, it is seldom necessary to readjust this control. During periods of reception the contacts of the relay short out the r-f gain control so that the receiver will operate at normal sensitivity.

While it has no bearing on safety in mobile operation, there is one characteristic of the mobile installation at W5CLP which might merit consideration by those persons concerned with the appearance and re-sale value of their automobiles. Unless they can be hidden in some way or another, holes drilled into the body of the automobile for the purpose of mounting a mobile antenna will seriously detract from the appearance and re-sale value of the car. In some automobiles it will be found that the back-up light is mounted in such a location that its removal will make adequate space available for mounting the antenna base *(Fig. 2-10-D)*. When the time comes to sell the automobile, it will be necessary merely to remove the antenna mount and to replace the back-up light. The back-up light will completely cover the holes which were drilled to accommodate the antenna base. Similarly, if forethought has been given to the location of the antenna mount in an automobile which is not equipped with back-up lights, the holes may be covered by installation of a back-up light before the car is sold.

Chapter Three

Mobile Receivers

3.1—Methods of Reception

To receive short wave signals in an automobile it is necessary to either extend the tuning range of the usual automobile radio receiver, or to install an entirely different receiver, capable of covering the amateur bands. There are advantages and drawbacks to each idea.

By far the most popular method of receiving amateur signals in mobile work is the use of a converter in conjunction with the car broadcast receiver. The car receiver serves as an i-f strip, second detector, audio amplifier and power supply.

Two different types of converters are in general use. The first and simplest type is the fixed-tuned converter.

Fixed-tuned Converter

A typical block diagram of a fixed-tuned converter is shown in *Fig. 3-1-A*. In the upper drawing a 28.5-Mc signal is received and heterodyned against a fixed frequency oscillator operating on 30 Mc. This oscillator may be crystal controlled for maximum stability. The output circuit of the detector is so tuned as to pick out the difference frequency created by the mixing action of the detector. This difference frequency is 1500 kilocycles, which may be tuned in on the car receiver. When a signal of 29.5 Mc. is received, as shown in the lower drawing, it is heterodyned against the 30-Mc oscillator to produce a difference frequency of 500 kilocycles. Thus the frequency range of 28.5 Mc. to 29.5 Mc. may be covered by tuning the car receiver from 1500 kc. to 500 kc.

Advantages of Fixed-tuned Converters

1. The conversion oscillator may be crystal controlled for maximum stability while the automobile is in motion.
2. The converter has no tuning controls and may be located out of sight in the automobile.
3. The converter may be constructed considerably smaller in size than the usual tunable converter.
4. The tuning dial of the broadcast receiver is used for amateur band coverage.

Disadvantages of Fixed-tuned Converters

1. The input circuit of the converter must be broad-banded for coverage of a complete amateur band. Image rejection

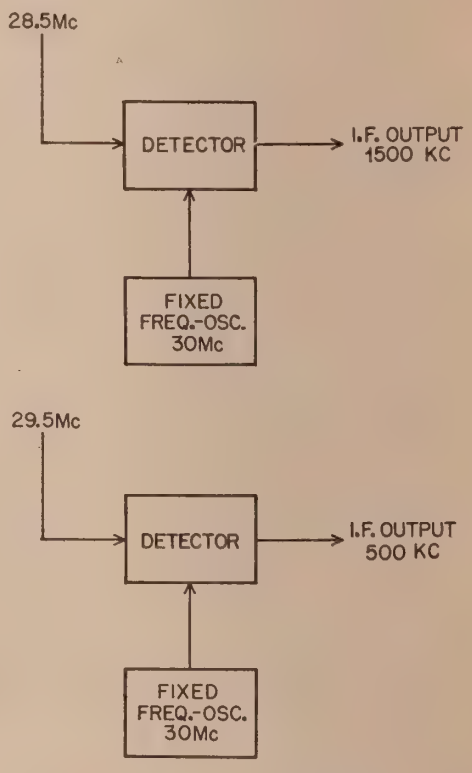


Fig. 3-1-A. Operating principle of a fixed-tuned converter. Note that the oscillator is not tunable.

is degraded below maximum performance.
2. The i-f output circuit must be broadbanded to cover 500-1500 kc. This usually means an untuned output circuit, leaving only the selectivity of the broadcast set to cope with any spurious responses.
3. There is a good possibility of "ride through" of local broadcast stations as the broadcast receiver is tuned across the dial.
4. The dial mechanism of the broadcast receiver may not be precise enough for accurate logging and tuning.
5. Image rejection ability becomes poorer as the broadcast receiver is tuned lower in frequency. The image frequency is continually changing and approaching the signal frequency.

In spite of the disadvantages, the fixed-tuned converter is very popular, especially for 28-Mc operation where the stability of the fixed oscillator is very important. An excellent converter of this type is described in *Chapter 3.3.*

Tunable Converter

The most widely used converter for amateur mobile reception is the tunable converter *(Fig. 3-1-B).* Here, in contrast to the fixed-tuned converter, the output i-f is constant. A frequency of 1500 kc. is used, since this affords the greatest image rejection obtainable in the standard broadcast range. To obtain the correct tuning range, the high frequency oscillator is variable, tuning over the same number of kilocycles as the detector input circuit. However, the oscillator tuning range is removed from the detector tuning range by an amount equal to the fixed i.f. Thus when the received signal is on 28.5 Mc., the oscillator is on 30 Mc., producing a difference frequency of 1500 kc. When the received signal is on 29.5 Mc., the oscillator must be on 31 Mc., again producing a difference frequency of 1500 kc. This difference frequency of 1500 kc. may be "spotted" on the automobile receiver as a fixed signal.

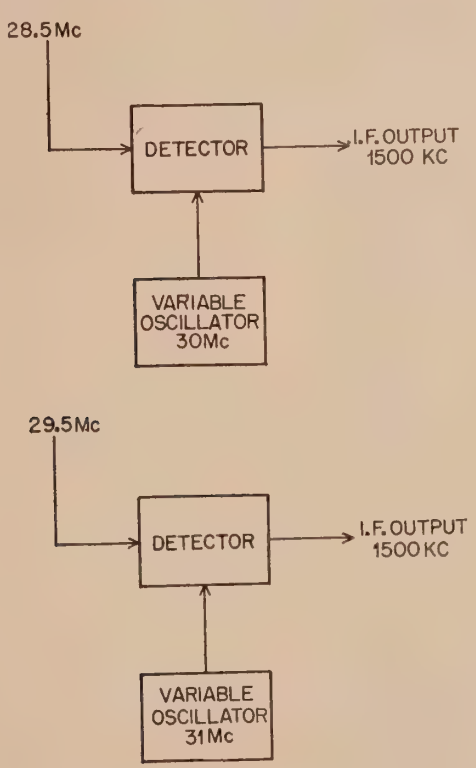


Fig. 3-1-B. Operating principle of a tunable converter. Note that in contrast to Fig. 3-1-A the first oscillator is tuned and the intermediate frequency remains constant.

Advantages of Tunable Converter

1. The detector and r-f stage of the converter may be ganged-tuned. A narrow band selective r-f stage can be used for highest image rejection and greatly reduced cross-talk.
2. The broadcast receiver is fixed tuned to 1500 kc., for best image rejection. The tuning dial of the broadcast receiver is not used.
3. The i-f output circuit of the converter may be peaked at 1500 kc., reducing spurious responses in the i-f system.
4. The converter may easily contain band-switching, whereas the fixed tuned converter is usually a one band device.
5. Danger of broadcast "ride through" is considerably reduced as the i.f. may be shifted slightly from 1500 kc. to avoid a local station.

Disadvantages of Tunable Converter

1. The tunable oscillator is relatively unstable compared to many fixed-tuned oscillator circuits.
2. Since the converter must be tuned, it must be located near the operator in an accessible position.
3. The physical size of the tunable converter is usually larger than that of the untuned converter.

In spite of these disadvantages, the tunable converter is the most popular variety for general amateur use. The oscillator instability may be largely overcome by proper design and the use of voltage regulator tubes in the plate supply of the oscillator. A converter of this type is described in *Chapter 3.8.*

Locating the Converter or Receiver in the Automobile

The location of the converter or receiver in the automobile is of the utmost importance. It should be easily accessible from the driving position, yet not block the entrance or exit nor inconvenience the operator or passenger. The three most popular mounting places for the receiving equipment are:

1. Attached to the Steering Column

A suitable clamp can be made *(Fig. 3-1-C)* of soft dural or sheet iron that will encircle the body of the converter and grasp the steering column. The face of the converter will mount about 5 inches behind and to the left of the steering wheel. The converter is tuned with the

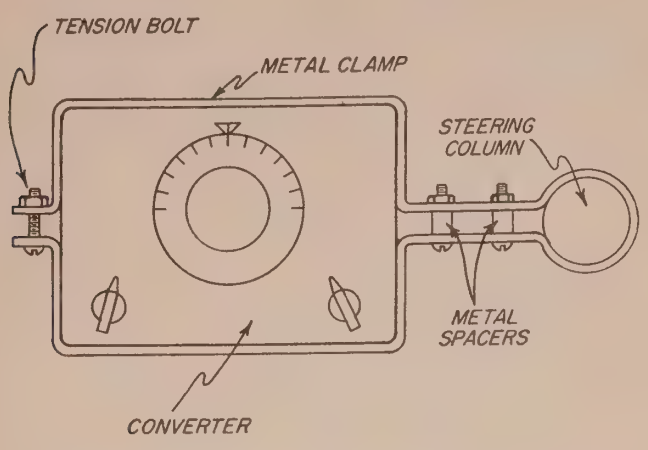


Fig. 3-1-C. A metal clamp may be easily fabricated to encircle the converter and strap it to the steering column.

left hand. By loosening the clamp the converter can easily be removed from the automobile for testing or servicing. (See *Fig. 3-1-D*)

2. Mounted Beneath the Instrument Panel

In many cars the converter may be mounted under the instrument panel. To permit easy removal of the converter it is suggested that it be held in place by a metal strap encircling the body of the converter.

3. Atop the Instrument Panel

The converter may be placed atop the instrument panel to the left of the steering wheel. Where it is not desired to disfigure the car, the converter may be held in place by a large rubber suction cup, whose lip has been coated with shellac *(Fig. 3-1-E)*.

Other less frequently used positions are: In the glove compartment, or below the broadcast receiver in the center of the car *(Fig. 3-1-F)*.

Adapting the Car Receiver for use with a Converter

For best operation of the converter it is necessary to add a noise limiter, and at the same time make some minor alterations to the car receiver. The installation of a noise limiter is thoroughly covered in *Chapter 4.0*. The minor alterations are:

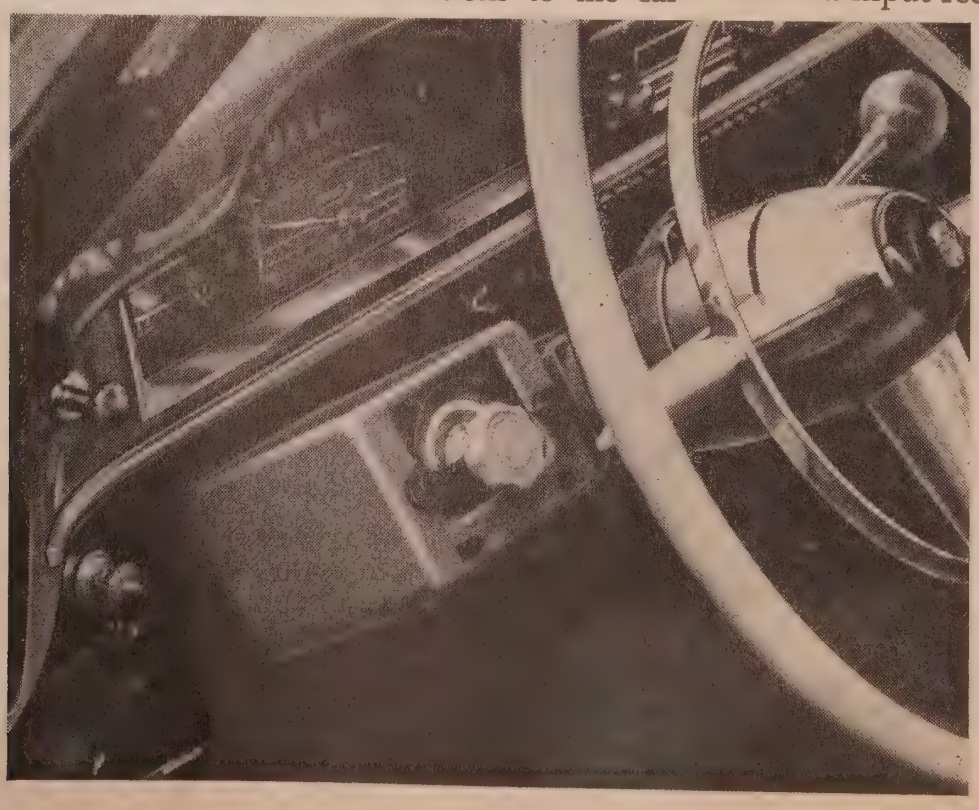
1. Power Connections

The power leads for testing the converter may be temporarily "haywired" to the broadcast receiver. Afterwards it is best to install a permanent octal tube or *Jones* socket on the broadcast receiver through which the plate and filament power for the converter may be obtained, and through which a muting system can be applied to the broadcast receiver to silence it during transmissions. The schematic diagram, *Fig. 3-1-G*, shows the necessary modifications to the broadcast receiver. A socket is mounted on a convenient space on the wall of the car receiver. A shielded cable from the socket will carry the power to the converter. *Pins 1* and *2* of the socket are grounded to the chassis of the car receiver. *Pin 7* is connected to the "hot" heater line. The filaments of the converter will then be turned on at the same time the broadcast receiver is turned on. A small 6-volt d-c relay, *R*, with normally closed contacts is mounted in the car receiver and is so connected as to open the B plus to both the converter and the last audio stage of the car receiver when *Pin 5* of the octal plug is energized.

All leads in the car receiver to the octal socket are bypassed by .001 μfd. ceramic disc condensers mounted on the socket. The cable leads from *pins 3, 5* and *7* should be made of shielded wire. The shields should be grounded to *pins 1* and *2* of the octal plug.

2. Alignment of the Automobile Receiver

After the converter is connected and is operating, the broadcast receiver should be retrimmed for maximum sensitivity in the vicinity of 1430-1500 kilocycles. On most car receivers an antenna trimmer control is mounted near the antenna input receptacle.



A convenient commercial steering wheel mounting is available from the Gonset Company. Mounting the converter in this fashion permits the driver to see the dial clearly and to tune it with his left hand while the automobile is in motion (Fig .3-1-D).

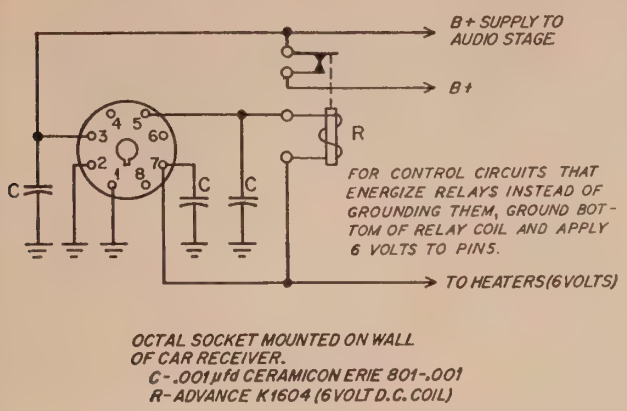

B+ SUPPLY TO AUDIO STAGE
B+
R
C
C
C
FOR CONTROL CIRCUITS THAT ENERGIZE RELAYS INSTEAD OF GROUNDING THEM, GROUND BOTTOM OF RELAY COIL AND APPLY 6 VOLTS TO PINS.
TO HEATERS(6VOLTS)
OCTAL SOCKET MOUNTED ON WALL OF CAR RECEIVER.
C-.001μfd CERAMICON ERIE 801-.001
R-ADVANCE K1604 (6VOLT D.C. COIL)

Fig. 3-1-G. An octal (or Jones) socket should be permanently mounted on the automobile broadcast receiver to supply power to the converter.

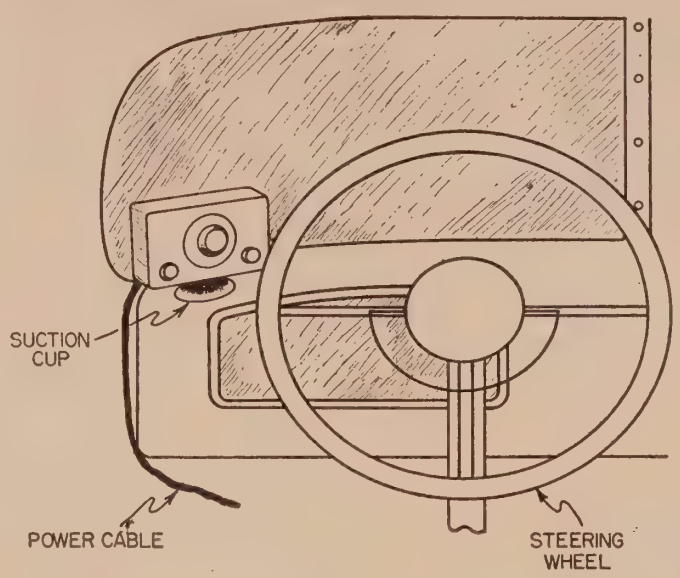


Fig. 3-1-E. If it is vitally necessary not to disfigure the dashboard or steering wheel, a large suction cup could be mounted on the bottom of the converter. The power cables should plug into the broadcast receiver.

If the receiver has a mechanical push button system, one button may be set to the output i.f. of the converter. Those receivers having electrical push buttons (wherein the push button substitutes a fixed-tuned preset circuit for the manual tuning circuit) should be tuned manually to the i.f., since such sets usually suffer a severe drop in gain when the fixed-tuned channels are used. This happens because fewer tuned circuits are used in the fixed-tuned channels than in the manual tuning channel.

Some of the late model automobiles are equipped with a signal seeking receiver which tunes progressively to each succeeding strong signal across the dial. In this case a switch should be installed on the side of the receiver to disconnect the signal seeking mechanism while the converter is in use.

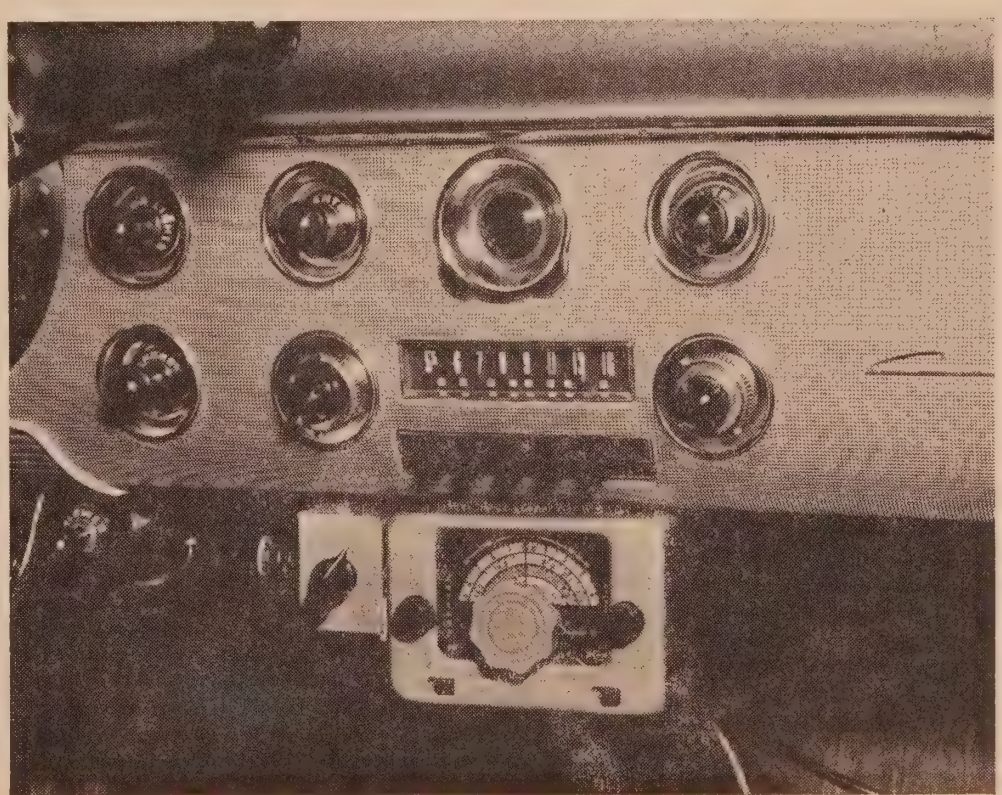
3. Connecting the Converter to the Receiver

The output lead from the converter to the input receptacle of the car receiver should be made of low capacity coaxial cable especially designed for automobile installations. The section that comes with the car receiver may be used if it is cut as short as possible. Special low capacity cable may be purchased in 18-inch lengths *(Ward No. C-9)*, for use in this application. Ordinary coaxial cable or shielded wire has too much distributed capacity to give the best possible results.

As a final step, the input and output circuits of the converter should be peaked to match the individual installation and antenna. An external signal source should be used for this operation.

Mobile Receivers

The converter/broadcast receiver is far from the ultimate in regards to selectivity, sensitivity and flexibility in mobile operation. The overall performance of the combination is limited



This is the installation of a casual operator, or someone likely to remain "spotted" on a net frequency. The under the dash mounting does not provide the maximum ease of tuning, but in certain models of our present-day cars it may be the only practical method. The additional box is for the TNS on the left of of the converter.
(Fig. 3-1-F)

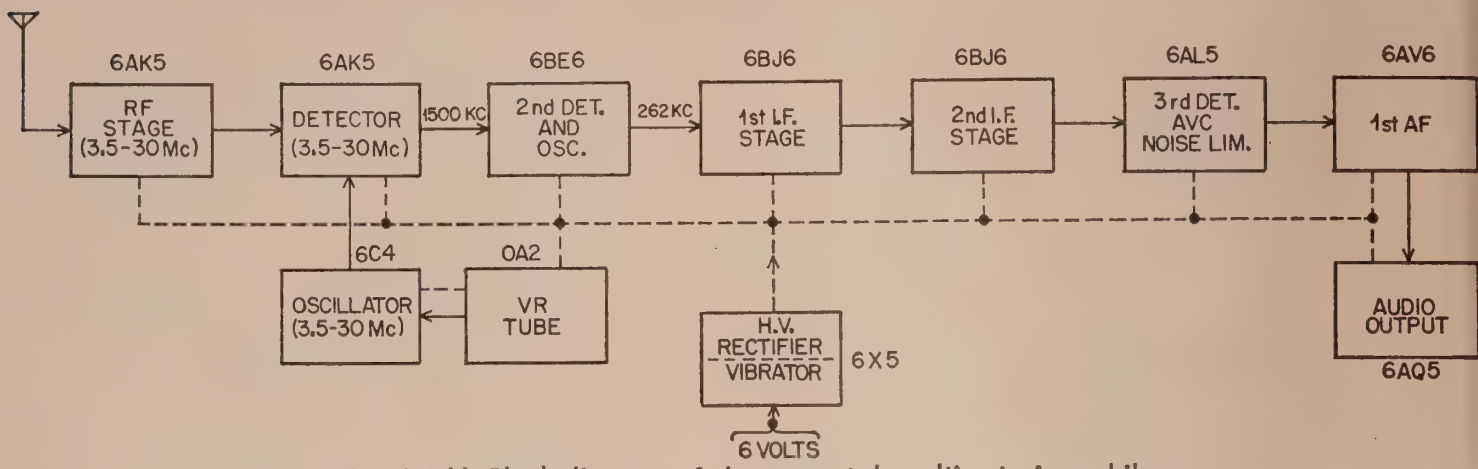


Fig. 3-1-H. Block diagram of the present-day ultimate in mobile receiver design. A receiver similar to this is described in Chapter 3.8.

by the capabilities of the broadcast receiver, which in many instances is not designed for a high order of selectivity or sensitivity. The addition of an "outboard" i-f stage will help somewhat, but will also add another piece of equipment to cram into the automobile.

A few of the more serious mobile operators employ a complete mobile receiver incorporating all the best features of a standard communications receiver. This provides a mobile receiver of the highest order.

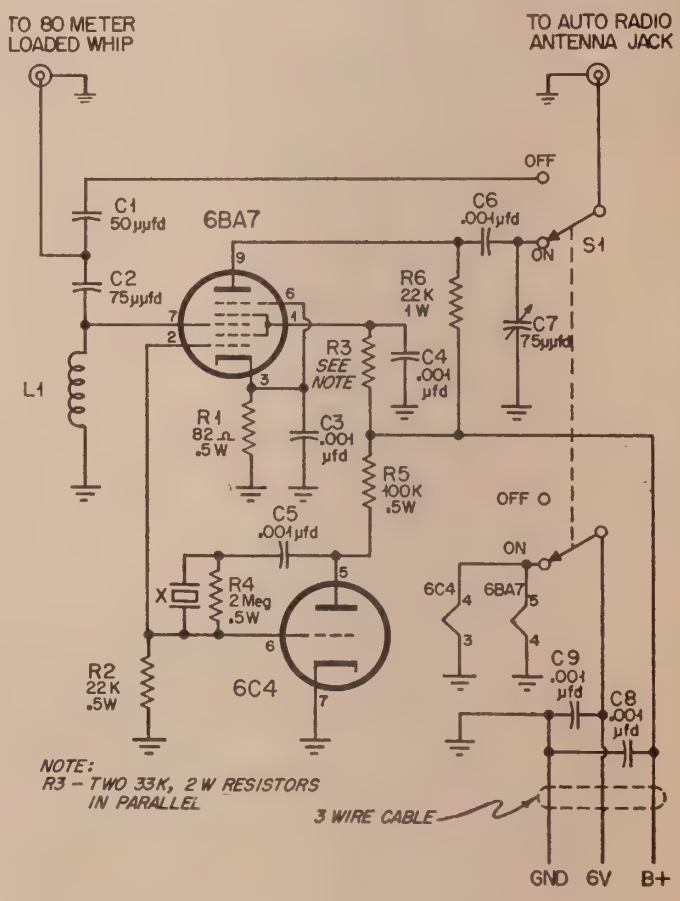
Figure 3-1-H illustrates in block diagram a typical mobile receiver. This receiver has a band-switching front end, tuning from 3.5-30 Mc. It has a tunable r-f stage, a voltage regulated h-f oscillator, dual conversion (1500 kc. and 262 kc.) for high selectivity, two i-f stages, a.v.c. and noise limiter, two audio stages and a self-contained speaker. It is comparable in performance to a high-grade home station communications receiver, and, using miniature parts may be made small enough for mobile work. The "Standard of Comparison" described in *Chapter 3.8* is such an ultimate design in mobile receivers.

The choice between a converter and a complete mobile receiver will depend largely upon whether mobile operations are approached as a part-time hobby, or whether the mobile installation is going to be the primary source of amateur operation. The complete receiver is the best solution, but also the most complicated and expensive.

3.2—A Fixed-tuned 75-meter Converter

The converter shown in *Figs. 3-2-A,* and *3-2-B* is designed for 75-meter phone operation. Under some circumstances the construction or purchase of a more elaborate converter may not be justified, and this small unit of this type will readily fill the bill. It is quite small and unlike the average converter, it is crystal controlled, all tuning being done with the car receiver. This characteristic offers the advantage that the unit may be mounted out of sight, perhaps on the fire wall or in the glove compartment.

The circuitry is shown in *Fig. 3-2-A*. The input circuit of this converter is a modified *pi*-network designed to work with the usual loaded 80-meter whip antenna. The response of this input circuit is such that the 75-meter phone



C1—50 μμfd., Erie GP-1K-500
C2—75 μμfd., Erie GP-1K-750
C3, C4, C5, C6, C8, C9—0.001 μfd., disc ceramic, Erie 801-001
C7—75 μμfd., mica padder, El-Menco #582
R1—82 ohms, ½w.
R2—22,000 ohms, ½w.
R3—two 33,000-ohm resistors, 2w., in parallel
R4—2.0 megohm, ½w.
R5—100,000 ohms, ½w.
R6—22,000 ohms, 1w.
S1—D.p.d.t. toggle
L1—National XR-50 forms wound with 47 turns of #28 DSC
Ant. Jacks are ICA #2378
X—2.0-3.0 Mc. xtal.
Box is a Bud CU-883

Fig. 3-2-A. Parts list and schematic of a 75-meter fixed-tuned converter.

Fig. 3-2-C. The coil L1 is close wound on a National XR-50 form. Mount condenser C2 temporarily across the coil and adjust the slug to resonate a 3900 kc. on a grid dipper.

band-edge point are reduced in response by only 3 db., a very negligible amount. The converter tube is a type 6BA7 operating as a straight mixer, the injection voltage to its No. 1 grid being supplied by a separate 6C4 oscillator. While admittedly the operation of the 6BA7 as combined mixer-oscillator would eliminate one tube, it has been determined that substantially improved performance is obtained when the injection voltage is supplied by a separate oscillator. This is particularly true when the operating voltages are low.

The 6C4 tube is connected as a conventional Pierce oscillator thus eliminating the necessity for additional tuned circuits. The crystal is connected from grid to plate of the tube with *C5* serving to keep the d.c. potential off the crystal and *R4* serving as a stabilizing load resistor. *R2* acts as a combination grid resistor for the 6C4 and as a load resistor for the No. 1 injection grid of the 6BA7 mixer tube.

The input inductor *L1* is wound on a *National XR-50* coil form and has an inductance of approximately 28 microhenries. It is composed of 47 turns of #28 DSC wire. This number of turns will exactly fill up the coil space on the form *(Fig. 3-2-C)*. The correct value of inductance is that value which will allow *L1* to resonate at 3900 kilocycles when paralleled by *C2*, the coil slug being half way into the coil. The coil winding and condenser specified will cover the range of 3.4 to 4.8 Mc. by tuning the coil slug. A commercial coil, *Miller No. 4508* could be used in place of the hand-wound *XR-50* as it is an exact match.

Greater gain can be achieved at a sacrifice of broad band characteristics by resonating the combination to some specific operating frequency, generally the frequency of resonance of the loaded whip antenna.

The switch *S1* is utilized to put the converter in or out of service. In the "OFF" position the 6-volt heater circuit is opened and the converter output is disconnected from the car receiver input. The car receiver is connected directly to the loaded whip. It will be advisable to arrange the wiring of the converter so that the capacity between the switch contact terminating

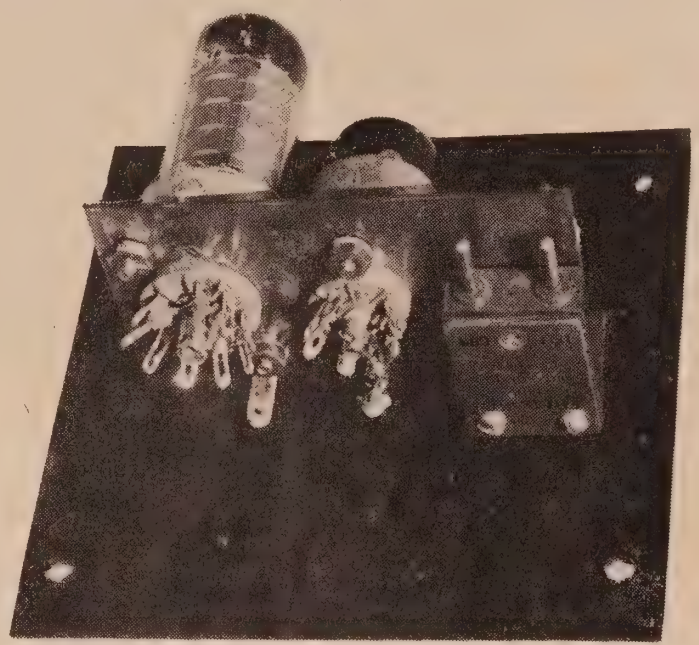


Fig. 3-2-E. A sub-chassis is mounted in the small cabinet before wiring. The crystal is "permanently" mounted to the sub-chassis by passing machine bolts through the two of the cover plate retaining holes.

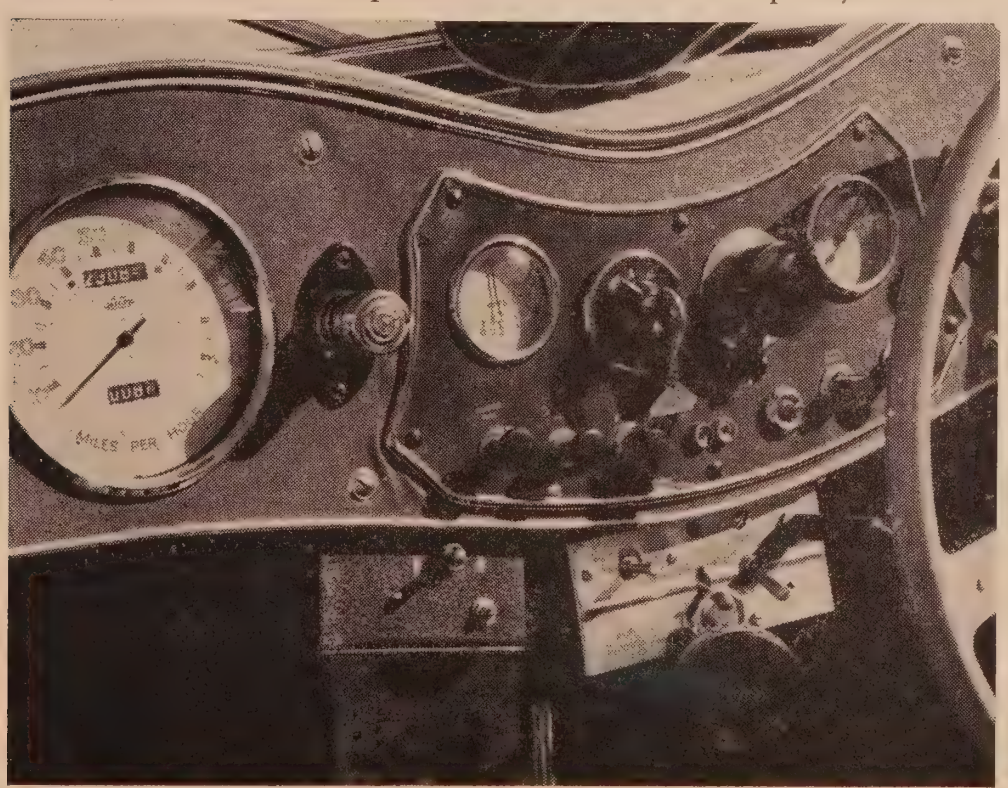


Fig. 3-2-B. The fixed-tuned 75-meter converter mounted under the dash of an "MG" sports car.

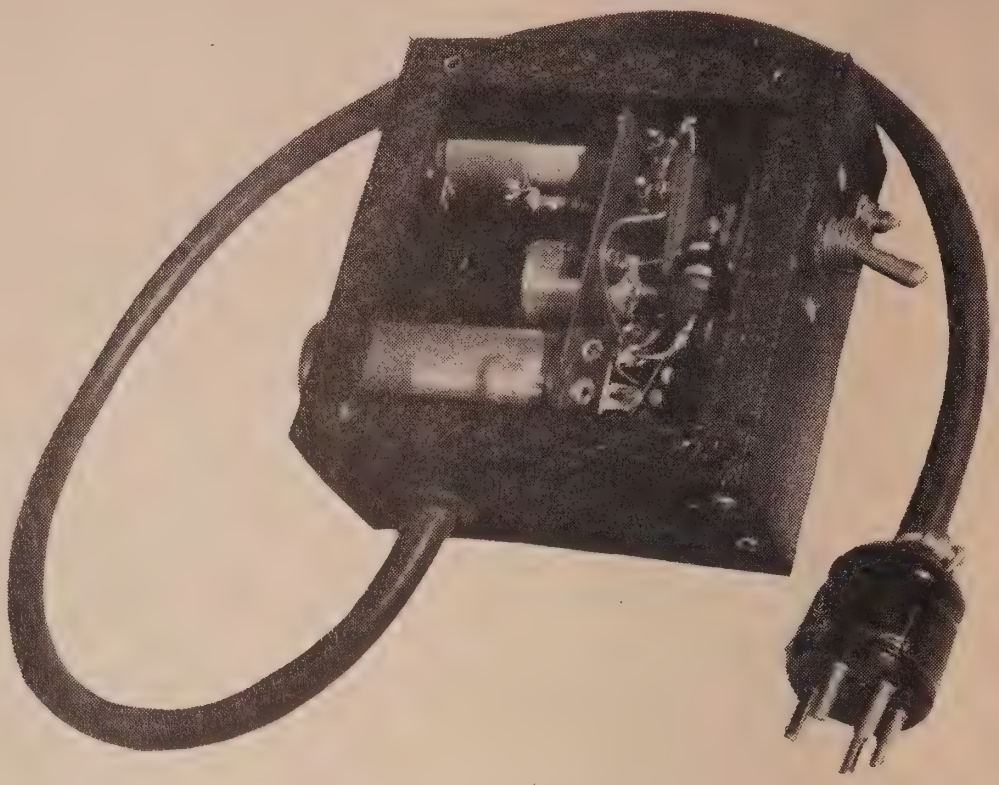


Fig. 3-2-D. The 75-meter fixed-tuned converter may be easily mounted in a small metal box (Bud CU-883). The 6BA7 tube is to the left in a full length shield. The 6C4 oscillator tube is in the center and L1 is on the right.

C1 and the car receiver input is at a minimum to avoid external pickup by the receiver when the converter is in use.

The region into which the 75-meter band will fall on the dial of the car receiver will be determined by the frequency of the conversion crystal. For example, a 3.0-Mc. crystal will position the phone band between 800 and 1000 kc. on the car receiver dial. A 2.5-Mc. crystal will place the phone band between 1300 and 1500 kc., and a 3.2-Mc. crystal will place the band between 600 and 800 kc. (Band edge frequency minus crystal frequency equals broadcast band dial frequency.) It is obvious that the particular choice of crystal frequency will depend to some extent upon which portion of the broadcast band strong local signals appear since "ride through" of a very strong local station is a possibility in this simple converter.

Construction

Construction of this converter is not difficult. The components fit easily within a standard 4" x 4" x 2" chassis box. A box should be chosen that has two removable sides *(Fig. 3-2-D)*. A small sub-chassis should be cut from dural or sheet brass to fit within the box *(Fig. 3-2-E)*. The sub-chassis measures 1¾" x 2¾" with a ⅜" lip. A clearance hole is cut in the box to allow the 6BA7 tube to extend through the rear wall of the box. In the interest of compactness no holder is used for the FT-243 crystal. It is secured to the sub-chassis by long machine screws that pass directly through two of the openings in the crystal cover plate formerly occupied by the cover retaining screws.

Wiring

The sub-chassis may be almost completely wired before it is placed in the box. Mount the 6BA7 socket with *pin No. 5* towards the lip of the chassis. Mount the 6C4 socket with *pin No. 3* towards the lip of the chassis. Mount the crystal as described above. An old octal tube socket may be taken apart to obtain two contact "fingers" for the crystal pins. The wiring

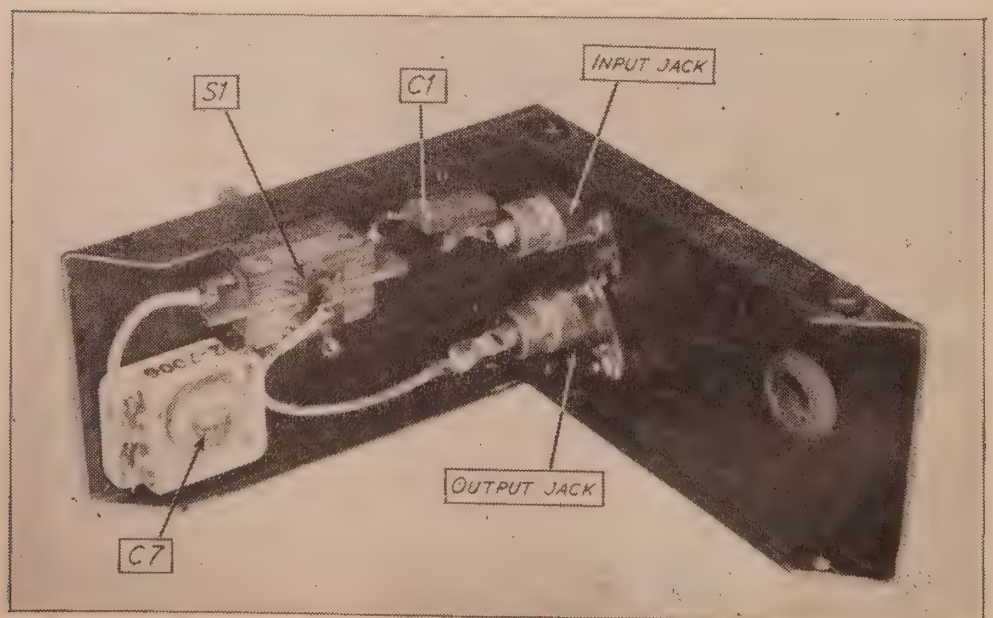


Fig. 3-2-G. In this cut-away view note the internal wiring of the box before the box and chassis are assembled.

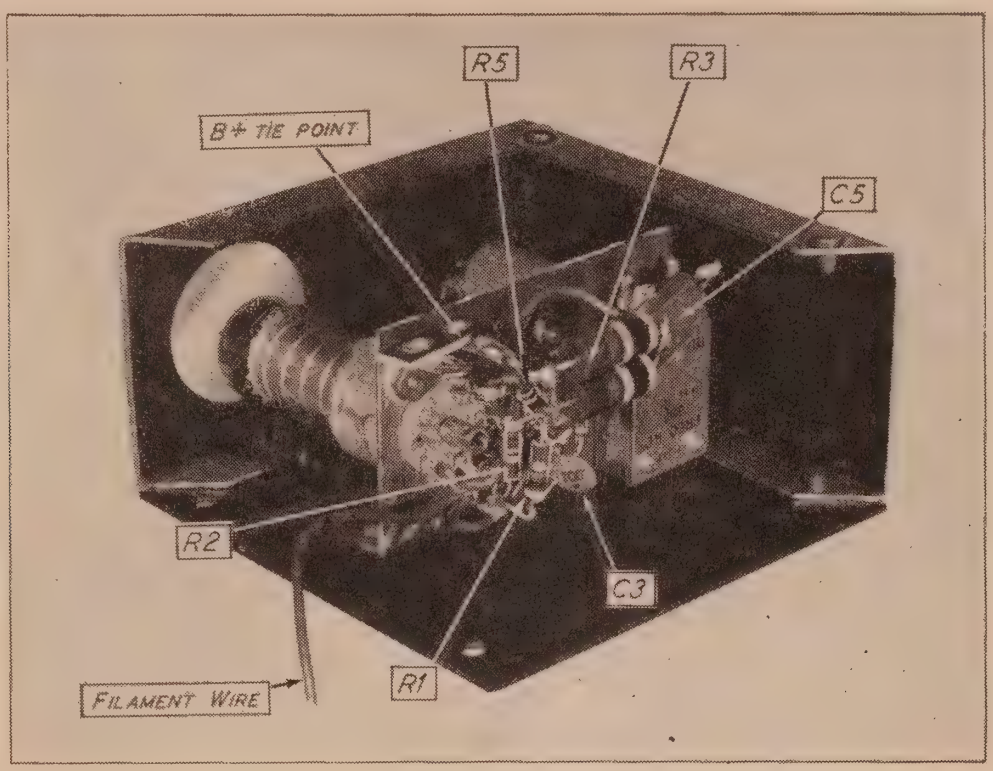


Fig. 3-2-F. This cut-away view shows the location of some of the components under the sub-chassis.

should proceed as follows:

1. Ground *pin No. 4* and the center stud of 6BA7 socket.
2. Ground *pins No. 3* and *No. 7* and the center stud of 6C4 socket.
3. Connect *pin No. 2* of 6BA7 socket to *pin No. 6* of 6C4 socket.
4. Wire *R2* from above jumper to ground lug under 6BA7 socket bolt nearest to *pin No. 4*.
5. Jumper *pins No. 3* and *No. 6* on 6BA7 socket.
6. Connect *R5* from *pin No. 5* of 6C4 to an insulated terminal point mounted on the free socket bolt of 6BA7.
7. Connect *R1* and *C3* from *pin No. 3* of 6BA7 to ground.
8. Connect *R4*, *C5* and jumper from crystal to *pin No. 2* of 6BA7 socket.
9. Connect *C4* from *pin No. 1* to ground lug on 6BA7 socket.
10. Connect *R6* from *pin No. 9* of 6BA7 socket to tie point.
11. Connect two 33,000-ohm two-watt resistors in parallel for *R3*. Connect one end of these resistors to the tie point. Allow the resistors to lie parallel to the edge of the sub-chassis. Jumper the free ends to *pin No. 1* of the 6BA7 socket with a short length of wire *(Fig. 3-2-F)*.
12. Jumper *pin No. 4* of 6C4 to *pin No. 5* of 6BA7. Attach a 6-inch lead to *pin No. 5* of 6BA7. This lead will go to *S1* when the sub-chassis is put in the box.
13. Turn now to the box: Wire *C1* and *C2* to one of the antenna jacks. Wire other end of *C1* to *S1*. Wire *S1* to output jack. Wire arm of *S1* to *C7*, which is mounted on front panel of box near *S1 (Fig. 3-2-G)*.
14. Attach a 6-inch lead to *pin No. 7* of the 6BA7 socket. This will attach to the free end of *C2* when unit is assembled.
15. Place sub-chassis in the box and bolt firmly into place, making sure a good electrical connection exists between sub-chassis and box. Complete wiring and attach *C8* at tie point. Attach *C9* at *S1*. Attach a three-wire cable running through the grommet hole in the rear of the box. Make this cable long enough to reach to the power plug on the automobile receiver.
16. Check all wiring to make sure no errors have been made.

After the converter has been wired and the wiring checked out it should be installed in the automobile for an operational test. Switch *S1* should be in the "OFF" position and antenna and power connections made to the converter. The antenna trimmer on the broadcast receiver should now be tuned for best response at 1500 kc. Switch *S1* should now be thrown to the "ON" position and trimmer *C7* peaked for best results at the 80-meter operating frequency. *L1* may be either adjusted for maximum gain at the operating frequency or may be left tuned to 3900 kc. for broad band operation. Either adjustment will provide very satisfactory operation of this compact converter.

3.3—Fixed-Tuned 10 Meter Converter

In addition to the feature of almost perfect stability, this converter offers accurate calibra-

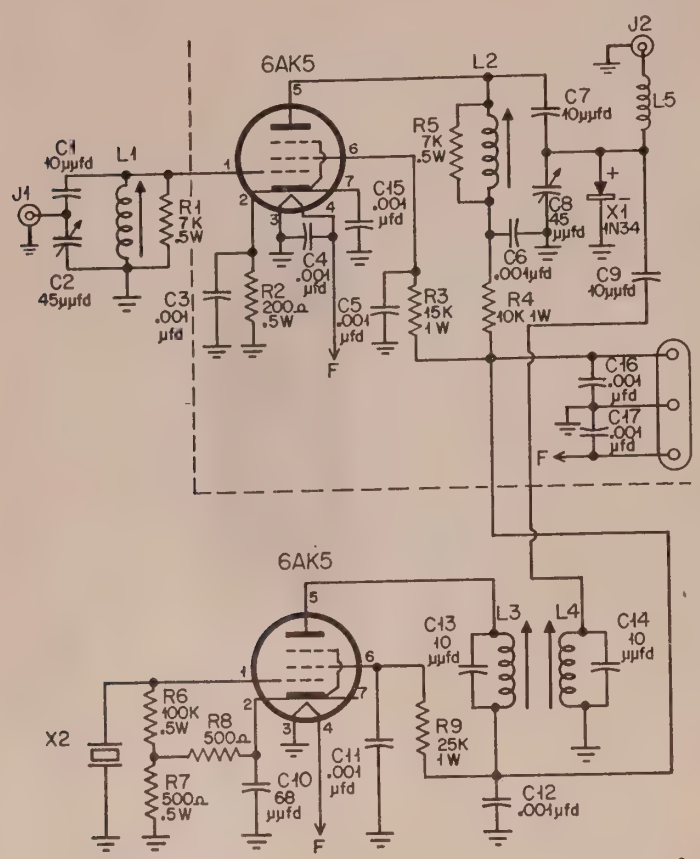


Fig. 3-3-A. Parts list and wiring schematic of the 10-meter fixed-tuned converter

C1, C7, C9, C13, C14—10 μμfd. ceramic, Erie GP1K-100
C2, C8—45 μμfd. ceramic trimmer, Erie TS2A-7
C3, C4, C5, C6, C11, C12, C15, C16, C17—0.001 μfd. ceramicon, Erie 800-001.
C10—68 μμfd. ceramic
R1, R5—7000 ohms, 1/2w.
R2—200 ohms, 1/2w.
R3—15,000 ohms, 1w.
R4—10,000 ohms, 1w.
R6—100,000 ohms, 1/2w.
R7, R8—500 ohms, 1/2w.
R9—25,000 ohms, 1w.
L1, L2, L3, L4—each 16 turns #26 DSC close wound on Millen #69041 form, or Miller coil #4503.
L5—25 turns #26 DSC close wound on a 1.0 megohm 1w.
X1—7.5 Mc. crystal
X2—1N34 crystal diode
J1, J2—antenna jacks, ICA #2378

tion and the same ease of tuning on the 10-meter band that one enjoys with the auto receiver in the broadcast band. The converter covers approximately 1000 kc. of the 10-meter band, and the proper selection of the oscillator crystal will allow either the high frequency end of the band or the low frequency end to be chosen, The 1000 kc. will appear between 550 and 1550 kc. on the automobile receiver.

A brief study of the schematic *(Fig. 3-3-A)* shows a 6AK5 tube operating as a broad band r-f amplifier. (Lest anyone balk at using a pentode amplifier at 28 Mc. after having read some of the literature on amplifier noise figures, it should be pointed out that cosmic radiation at 30 Mc. generates noise in a dipole antenna some 40 times greater than thermal noise, so that for 10 meters a mobile receiver noise factor less than 10-12 db. is largely a wasted effort.)

A 1N34 crystal mixer works in conjunction with a 6AK5 crystal oscillator which quadruples from the 7.5-Mc region to 30 Mc. The coupling coils *L3* and *L4* are tuned to 30 Mc. and serve to attenuate the undesired harmonics from the 7.5-Mc crystal. From *L4 the* 30-Mc output is fed through *C9* to the output circuit of the 6AK5 tube where it is mixed with the incoming 10-meter signals in the 1N34 crystal converter. Hence a 28.5-Mc signal is mixed with the 30-Mc oscillator harmonic and the resultant frequency is tuned in on the car receiver at 1500 kc. A 29.4-Mc signal will appear at 600 kc. on the car receiver. Using a crystal with a fundamental frequency of 7562 kc. the range 28.7 to 29.7 mc. will be covered by the converter. Image rejection is no problem as the oscillator frequency is on the high side of the 10-meter band and falls in a region of little activity.

The use of a 1N34 mixer effectively prevents "ride through" of broadcast band signals when the converter is being used. No attempt should be made to substitute a high gain conventional

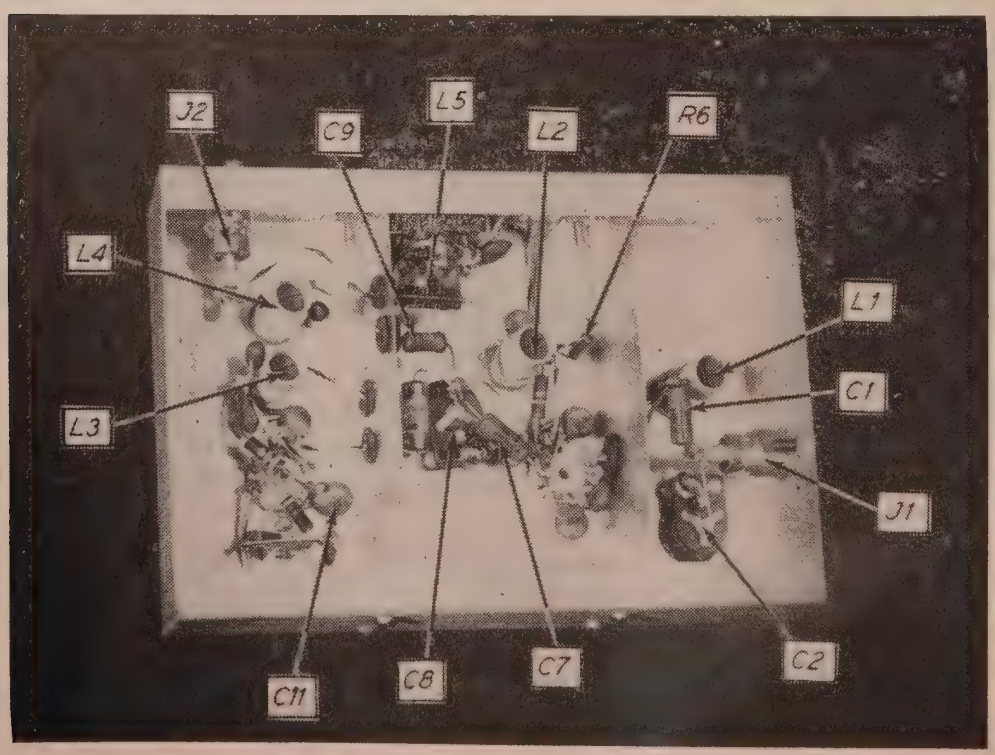


Fig. 3-3-B. Under chassis view of the 10-meter converter.

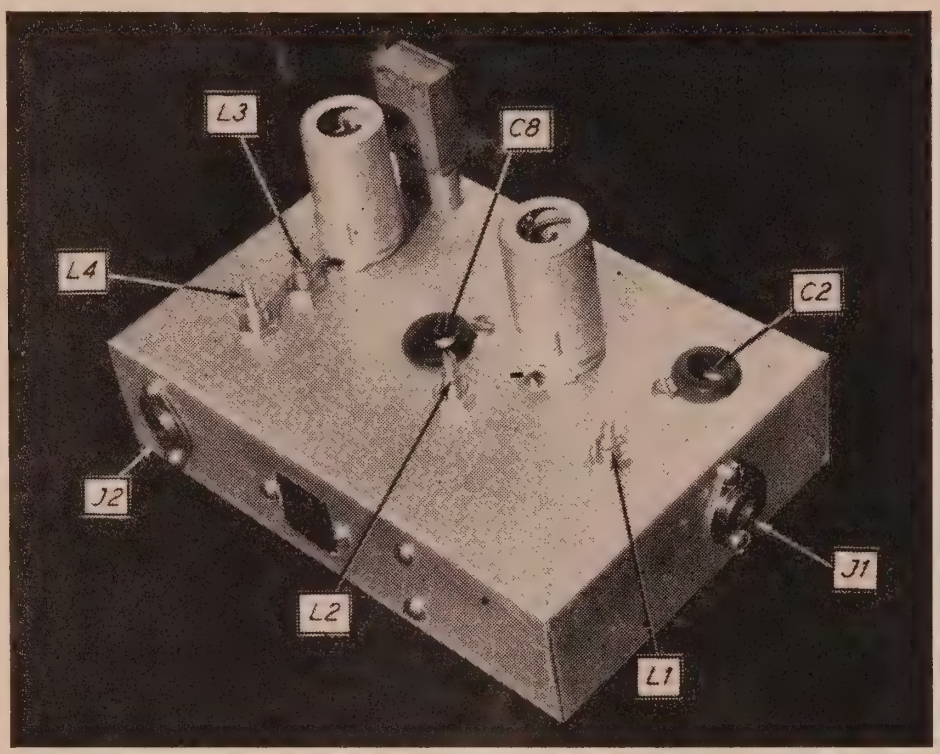


Fig. 3-3-C. Top view of the 10-meter fixed-tuned converter. The oscillator is crystal controlled for maximum stability. The mixer is a 1N34 crystal diode in order to minimize "ride through" of broadcast stations.

vacuum tube converter for the 1N34. Because of the high gain of the 6AK5 amplifier stage care should be taken to shield the grid circuit of the 6AK5 from the plate circuit components.

Construction

A commercial aluminum chassis 6" x 4" x 2" *(Bud AC-431)* is used for the converter. It is divided into three compartments by two homemade aluminum shield plates *(Fig. 3-3-B)*. The shield for the 6AK5 grid circuit mounts very close to the grid pin of the 6AK5 tube socket with a small hole cut in the shield to allow the grid prong of the tube socket to extend into the grid compartment. This compartment contains the coaxial input plug *J1,* the grid coil *L1,* the resonating condensers *C1* and *C2* and the loading resistor *R1*. The center compartment contains the 6AK5 tube socket and the condensers and resistors associated with the 6AK5 r-f stage. It also contains the plate coil *L2,* the resonating condensers *C7* and *C8,* and the plate bypass condenser *C6*. The third compartment contains the crystal oscillator tube, the crystal *X1,* the harmonic coils *L3* and *L4* and the 1N34 and its associated components. Colis *L3* and *L4* may be either hand made on *Millen 69041* coil forms, or may be manufactured units such as the *Miller No. 4503*. The coils are so mounted that the windings are separated by about ¼ inch.

Coil *L5* acts to prevent the low input impedance of the average car receiver from shorting out the 1N34 detector. It also isolates the high frequency components being mixed in the 1N34 from the car receiver input circuit, yet allows the 550-1500 kc. intermediate frequency signals to pass from the converter to the car receiver. *L5* may be wound around a 1-watt 1-megohm resistor which will serve as an excellent coil form.

Figure 3-3-C shows the general chassis layout of the converter. Looking at the top of the chassis it will be noted that there are two grommet holes for adjusting *C2* and *C8*. Each of these condensers is mounted by one lug to a *6-32* bolt in the chassis. The adjustment screws for *L1, L2, L3* and *L4* also come through the top of the chassis. Filament and plate power is fed to the converter through a socket mounted on the back of the chassis in the center compartment. The output coaxial line from the converter may pass thru a d.p.d.t. rotary switch mounted near the car receiver which switches either the converter or the broadcast antenna to the car receiver. This switch would also turn on the filament power to the converter.

Adjustment and Installation

The plate voltage to operate the converter is not critical and any voltage between 150 and 250 volts that may be stolen from the car receiver is satisfactory. Adjustment of the converter is very simple. If the circuit constants are followed, the plate circuit of the oscillator will immediately tune to the fourth harmonic of the crystal, so it is only necessary to peak *L3* and *L4* for maximum received signal when the converter is connected and in operation. Next, the trimmers *C2* and *C8* are peaked for maximum sensitivity. With the broadcast receiver tuned to approximately 1000 kc. *L1* and *L2* should be adjusted for maximum gain and then *C2* and *C8* repeaked. A final adjustment of *L1* should be made after the installation is complete and the correct length of coaxial line is used to connect the converter to the 10-meter whip antenna. If these adjustments are made with the car receiver tuned to the middle of the band the gain of the converter will be practically uniform over the entire band. No tuning adjustments are necessary when changing from a 7500-kc crystal to a 7562-kc crystal.

3.4—The W2AEF Converter-ettes

With the opening of the 15- and 40-meter bands to phone operation, and with Class B license phone operation now permitted on 20 and 75, many mobile operators, desiring to take advantage of the new regulations, may find themselves without a means of reception on these bands. Also, there may be others desiring to enter the mobile field, but who may be held back from doing so for lack of an inexpensive method of reception. An inexpensive and simple receiving arrangement may also be desirable for use in automobiles serving as auxiliary listening units in connection with CD work.

The *Converter-ettes,* such as described herein, are ideal units to cope with the situation. They are simple two tube fixed-tuned converters of high sensitivity, which may be tucked away behind the dashboard, under the seat, in the trunk, or in the glove compartment. Tuning over the range of a band is done with the dial of the automobile broadcast receiver. The *Converter-ettes* have each been designed for single band operation.

The R-F Stage

The circuit diagram for the *Converter-ettes* is shown in *Fig. 3-4-A*. The r-f stage employs a 6BH6 pentode, the grid circuit of which is peaked to the center of the band by means of the slug in *L2*. Response is sufficiently broad for satisfactory gain over any one band. From the coil table it will be noted that fixed capacitors are added across both the r-f and mixer inductors for some of the bands.

The 6BH6 was chosen for the r-f stage, because it provides high gain with a noise figure lower than that found with other tubes tried in this particular arrangement. The 6CB6, 6AK5, 6BA6, 6AU6, etc., may be used since from the practical standpoint, the attainment of the lowest noise figure may be a bit superfluous as far as mobile operation is concerned.

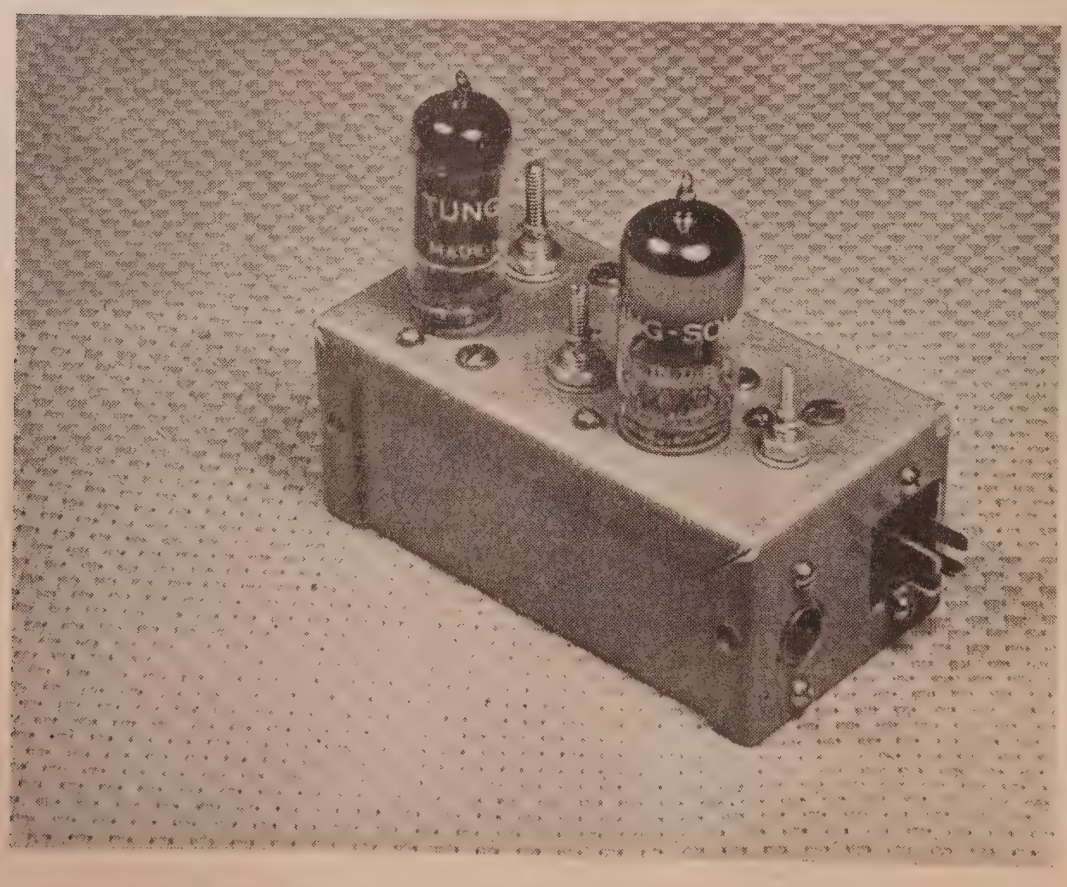
For CD work, or for other cases where very strong local signals may be encountered, provision has been made to use a.v.c. on the r-f stage to reduce front-end overloading and cross modulation.

The Mixer

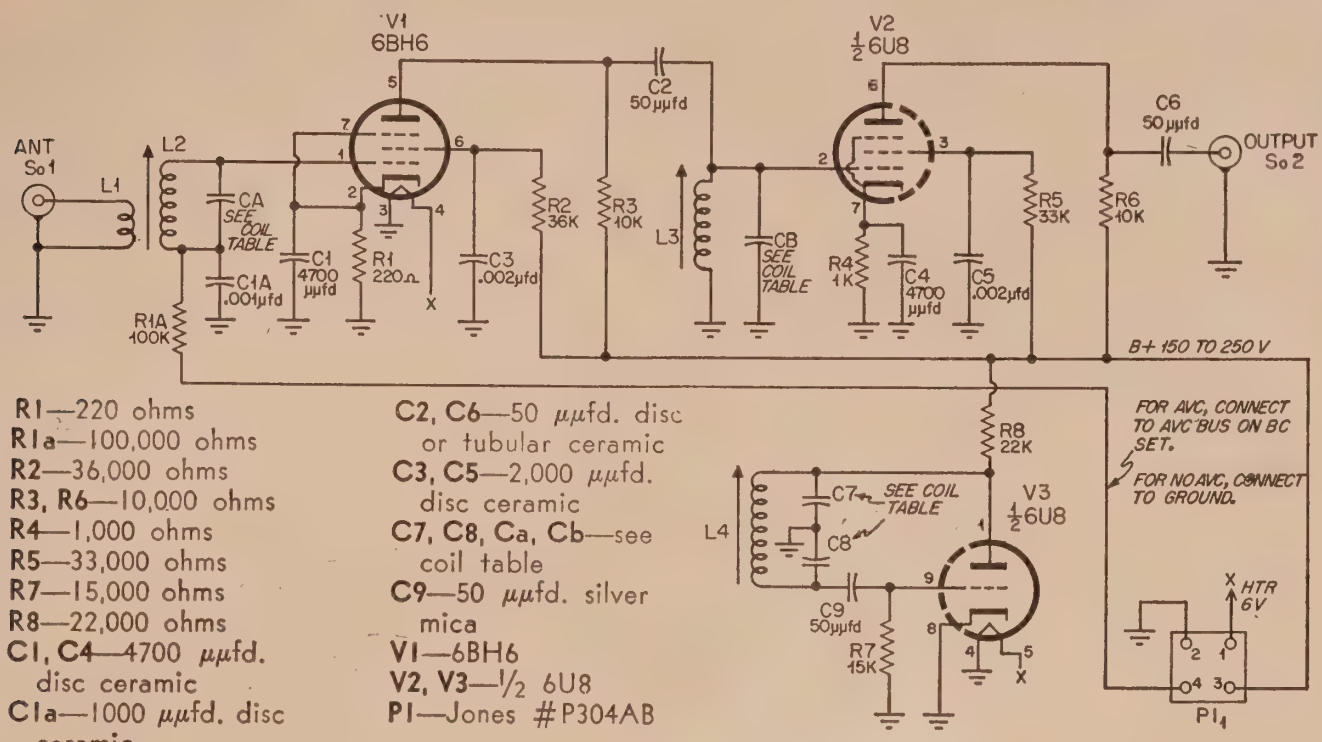
The mixer-oscillator employs a 6U8 triode-pentode dual-purpose tube. The pentode section is used as the mixer, while the triode portion is used as the h-f oscillator. Other mixer tubes such as the 6X8 and the 6BA7 were tried, but the 6U8 provided the best all around performance consistent with high gain, low noise oscillator stability, and minimization of oscillator pulling, to be found in one tube.

It will be noted that the output of the 6U8 mixer tube is fed directly to the input of the auto radio through a resistance coupled coaxial line. No special output circuits or low impedance links are required. This manner of coupling furnishes an output level higher than that found with some of the more conventional methods; in fact, the output from the *Converter-ette* is so high that in many installations it may be necessary to pad it down to prevent overloading and excessive a-v-c action in the broadcast set from only average ignition noise pulses.

The h-f oscillator employs a fixed tuned Colpitts circuit. Stray oscillator coupling to the mixer is sufficient through the tube capacitances. Similar types of broadband converters often employ crystal oscillators to realize stability, however, the oscillator used in the *Converter-ettes* has proven to be very stable, and no voltage



The Converter-ette may be built into a small BUD Mini-box. Each unit is complete for tuning one amateur band with the automobile receiver as a tuneable i-f system. Converter-ettes may be made to plug into a rack fitting for band changing.



R1—220 ohms
R1a—100,000 ohms
R2—36,000 ohms
R3, R6—10,000 ohms
R4—1,000 ohms
R5—33,000 ohms
R7—15,000 ohms
R8—22,000 ohms
C1, C4—4700 μμfd. disc ceramic
C1a—1000 μμfd. disc ceramic
C2, C6—50 μμfd. disc or tubular ceramic
C3, C5—2,000 μμfd. disc ceramic
C7, C8, Ca, Cb—see coil table
C9—50 μμfd. silver mica
V1—6BH6
V2, V3—½ 6U8
P1—Jones #P304AB

Fig. 3-4-A. Parts list and wiring schematic for the Converter-ette.

regulation is required. This is possible because of the use of good components plus the high *C* oscillator circuit. The high *C* also reduces oscillator harmonics and thereby minimizes the possibility of image reception of signals from harmonically related high frequency bands.

Construction

The construction of the *Converter-ettes* is easy and quite straightforward (see *Fig. 3-4-B*). They are built on 4" x 2⅛" v 1⅝" chassis *(Bud Minibox)*. An aluminium shield, 1⅞" wide and 1½" high, separates the r-f stage from the mixer-oscillator section. The r-f section contains the following components, besides the tube socket for *V1: L1, L2, C1, CIA, C3, R1, R1A, R2* and *S1*. A three-terminal tie strip is mounted along the mixer side of the chassis. One end of *R2* is connected directly at the socket of *V1, pin 6;* and the other lead of *R2* is insulated, and, after passing through a ¼" hole in the shield, is connected to a common B plus terminal on the tie strip in the mixer section. One lead of *R3,* located in the mixer section, is connected directly to the common *B* plus tie point. The other lead of *R3* is insulated, and after passing through a separate ¼" hole in the shield, is connected directly to the socket of *V1, pin 5.* One lead of *C2* is connected to the end of *R3* before the latter passes through the shield hole, and the other lead of *C2* connects to the grid terminal of *L3* which is located near the shield partition. This grid terminal is the end of the winding at the top of *L3*. The ground side of *L3* is located at the end of the winding nearest to the chassis.

R5, R6 and *R8* are connected directly between their respective terminals on the *V2* socket and the common *B* plus tie point. The heater lead for *V1* is also brought through a separate small hole in the shield, and is connected to a common heater tie point terminal.

R1, R4 and *R7* are installed right at their respective socket terminals. They lie near the chassis with their ground ends connected to soldering lugs secured by the socket screws. One end of *R1A* is connected directly at the bottom end of *L2,* the other end is connected to an insulated wire which is connected to an a-v-c tie point terminal in the mixer section.

The oscillator capacitors, *C7* and *C8,* are installed vertically along the side of *L4,* away from the chassis to minimize heat pickup and to allow free air circulation around them. They are firmly secured by a short lead to a ground lug. The plate end of *C7* should be connected directly to the terminal on *L4* nearest the chassis. *C9* should be connected to the grid terminal of *L4* (the one farthest from the chassis) by a very short lead, leaving the longer lead to be connected to the tube socket. *C1, C1A, C4, C5* and *C6* are installed last.

Power leads for the *Converter-ette* are connected directly to a *Jones* plug mounted on the chassis, so that *Converter-ettes* for different bands may be plugged in at will.

Tube shields are not used, because they are not required, and because their use would transmit an excessive amount of heat from the tubes to the chassis. Good quality ceramic or mica-filled sockets hold the tubes securely in place without the aid of shields.

Adjustment and Operation

For 28-Mc band operation, the oscillator should be tuned to approximately 28 Mc. This may be done by using a grid-dipper, no power being applied to the oscillator, but with the tube in the socket. With power applied, the oscillator may be checked for oscillation while

Frequency	L1	L2	Ca	L3	Cb	L4	C7 & C8 (silver mica)
28 Mc.	2 turns #20 plastic	19 turns #24 en.		17 turns #24 en.		14 turns #26 en.	100 uufd.
21 Mc.	2 turns #20 plastic	20 turns #24 en.	5 μμfd.	18 turns #24 en.	5 μμfd.	18 turns #26 en.	100 μμfd.
14 Mc.	3 turns #20 plastic	25 turns #28 en.	10 μμfd.	25 turns #28 en.	10 μμfd.	22 turns #28 en.	100 μμfd.
7 Mc.	6 turns #24 en.	45 turns #34 en.	10 μμfd.	45 turns #34 en.	10 μμfd.	35 turns #32 en.	200 μμfd.
4 Mc.	16 turns #34 en.	100 turns #36 en.	10 μμfd.	100 turns #36 en.	10 μμfd.	75 turns #36 en.	200 μμfd.

L1 --wound around bottom turns of L2, first wrap scotch tape around L2.

L2 & L3 --wound on 3/8" dia. slug-tuned ceramic forms -- CTC LS5

L4 --wound on 1/4" slug-tuned ceramic form, CTC LS6

Converter-ette coil winding data.

using the grid dipper as an absorption type frequency meter. For better accuracy, another receiver tuned to 28 Mc. may be used, in which case the oscillator slug in *L4* should be adjusted until the beat may be heard in the receiver.

When the *Converter-ette* is used with a broadcast receiver, the h-f range will be 28 Mc. *plus* the frequency to which the broadcast receiver is tuned. As an example, if the BC set covers 500 to 1600 kc., the h-f range will be 28.5 to 29.6 Mc. The low frequency range on many BC sets begins at 550 kc. in which case the h-f range would start at 28.55 Mc. In this case, if it is desired to cover down to 28.5 Mc., the oscillator frequency of the *Converter-ette* will have to be lowered to 27.95 Mc. This, of course, will also reduce the upper frequency limit. If it is desired to bring the top of the range to 29.7 Mc. then the oscillator frequency will have to be raised to 28.1 Mc.

Next, if a grid dipper is available, remove the heater and plate power from the *Converter-ette* and peak the r-f and mixer inductors to approximately 30.5 Mc. Apply both heater and plate power to the unit. Recheck the inductors by using the grid dipper. Because of the loading of the tubes on the low *C* circuits, the *Q* will be lowered, and it may be difficult to obtain an indication on the grid dipper meter. If a dip is readable, the frequency will be lower because of the change of the tube capacitances when power is applied. The new resonances should fall near, or be adjusted to, the center of the band.

If a grid dipper is not available, the mixer and r-f inductors should be tuned as follows: (final retrimming should be made in this manner in any case). Connect the output of the *Converter-ette* to the input of a receiver having an *S*-meter which may be used as a visual peak indicator. If it is necessary to use a receiver not having a meter, disable the a-v-c circuit and use the loudspeaker or headphones to make peaking adjustments by ear. Do not connect any antenna to the *Converter-ette* at this time. Set the receiver near 1000 kc. Apply power to the *Converter-ette,* and make sure its oscillator is functioning at the correct frequency. Back off the

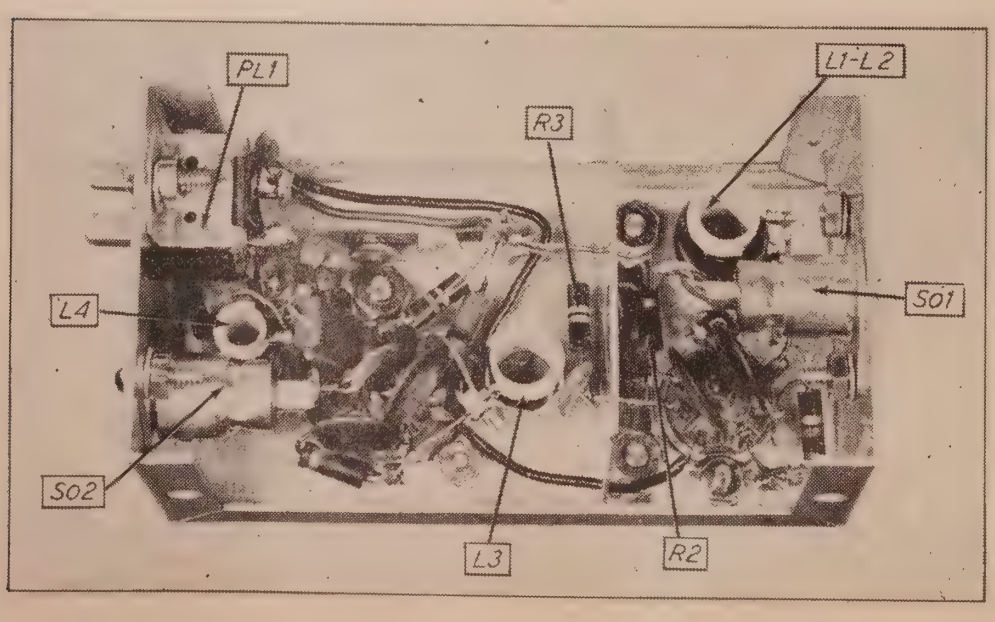


Fig. 3-4-B. Under chassis view of the Converter-ette showing the location of some of the more important components.

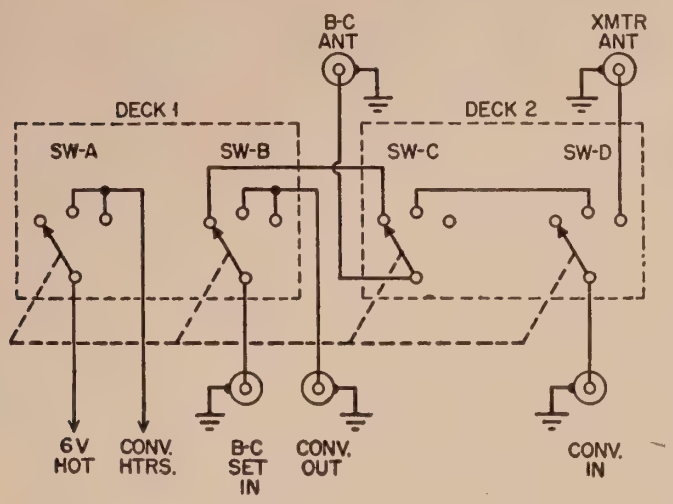


Fig. 3-4-C. A separate switching circuit provides a choice of antennas for broadcast reception as well as switching the Converter-ette into the broadcast receiver.

slugs in *L2* and *L3* all the way counterclockwise. This is the highest frequency position. Now tune *L3* (mixer) slug clockwise until the thermal noise peaks, as indicated by the *S*-meter or the receiver. Note this point and again rotate the slug clockwise until a *second* noise peak is found. This second peak will be that on the *low frequency* side of the h-f oscillator and it is the *incorrect* one to use, but it should be checked in this manner so that it may be found which frequency actually is being peaked. Now rotate the slug back counterclockwise to the *first* peak originally encountered.

Next tune *L2* (r-f) *slug* clockwise until the noise is peaked further. This should be the correct point on the high frequency side of the h-f oscillator, but the following additional check should be made:

First note the number of turns required from the maximum counterclockwise position to the point where the peak just found on *L2* has been determined. Then set the slug back at maximum counterclockwise, and tune the slug in *L3* (mixer) clockwise to its second or *incorrect* peak as described above. Then tune *L2* for a maximum peak, and count the number of turns from maximum counterclockwise at which the peak occurs. This should be a *greater* number of turns than counted with the first peaking of *L2*. Both settings of *L2* and *L3* will be the incorrect ones, since they are both tuned to the low frequency side of the oscillator, or at the image of the desired frequency. Here again, this operation is advisable just to check the correct peaking points.

Finally, set both slugs back to their maximum counterclockwise positions, and proceed to tune them to the *correct* points by selecting the first peak (tuning in the clockwise direction) with *L3* (mixer), and then by peaking *L2* (r.f.) at the number of turns first counted. When the antenna is connected to the *Converter-ette,* it may have some slight reactance which may be tuned out by slightly repeaking *L2*.

Frequency Calibration

Final frequency calibration should be checked by tuning in signals of a known frequency. If the h-f oscillator is operating at exactly 28 Mc., the dial of the broadcast set will serve as the calibration for the whole band, and reference may easily be made by adding the broadcast frequency to 28 Mc. A reading of 600 kc. on the dial then becomes 28.6 Mc., 700 kc. becomes 28.7 Mc., 800 kc. becomes 28.8 Mc., etc. If the h-f oscillator has to be shifted to take in the extremes of the band, as described earlier, then the dial calibration will be different by the amount the oscillator has been shifted.

The *Converter-ettes* for the other bands are lined up by following the same procedure as for 28 Mc., with the oscillator frequency tuned to the desired frequency *minus* the frequency to which the BC set is tuned. For example, on 14 Mc. it may be desirable to select 1000 to 1400 kc. for the tuning range so that the calibration will fall in line, making 1000 kc. equal to 14 Mc., 1100 kc. equal to 14.1 Mc., etc. In this case the h-f oscillator must be tuned to 13 Mc.

On the other hand, the bandspread of the BC set may be too cramped in this range, in which case it may be more convenient to use, say, 600 to 1000 kc. as the range. It is suggested that the range having the greatest bandspread be used, and if the BC dial is quite uniform, giving a choice of ranges, it is best to select the highest frequency end to obtain the best image rejection. Final peaking of the r-f and mixer inductors of the *Converter-ette* should be made at the center of the band used.

Installation

Upon installation in the automobile, any length of shielded antenna cable may be used to connect the *Converter-ette* to the BC set. In most cases it may be desirable to provide a switching arrangement, with appropriate shielded connectors, to change between *Converter-ette* and BC reception. This switching unit may be made up in a separate small box which may be mounted in an inconspicuous, but convenient, place. The circuit for one such arrangement is shown in *Fig. 3-4-C*. A three position switch is used which permits the choice of normal broadcast reception on the BC set, or h-f reception through the *Converter-ette*. It also provides a choice of using either the normal broadcast antenna or the transmitting antenna on the *Converter-ette*. In addition, the heater supply for the *Converter-ette* is connected through to the BC set whenever the switch is placed in one of the h-f positions.

It will be seen that the broadcast antenna line is broken at two points through switches *B* and *C*. This, together with the separate switch decks, eliminates any possible leakage to the BC set of broadcast signals which otherwise might creep in when the *Converter-ette* is used.

If, when power for the *Converter-ette* is obtained from the BC set power supply, it is found that feedback or motorboating occurs when an h-f signal is tuned in, a decoupling filter should be installed between the *Converter-ette* and the BC set. This may be done at the BC set. The filter should consist of a 1-watt 2000-ohm resistor in series with the *B* plus lead to the *Converter-ette,* with an 8 μfd electrolytic capacitor connected between ground and the *Converter-ette* side of the resistor.

In certain cases the output from the *Converter-ette* may be too high causing overloading or excessive a-v-c action of the BC set. This may be reduced by padding down the output of the *Converter-ette* by means of a resistor connected between the output side of *C6* and ground. The resistor will vary in individual cases, ranging from 100 to 3000 ohms. To find the correct value, set the volume control slightly above normal operating level, and disconnect the antenna from the *Converter-ette*. Then try different size resistors until the one is found which drops the thermal noise down to where it can just be heard.

3.5—One-Tube Four-Band Converter

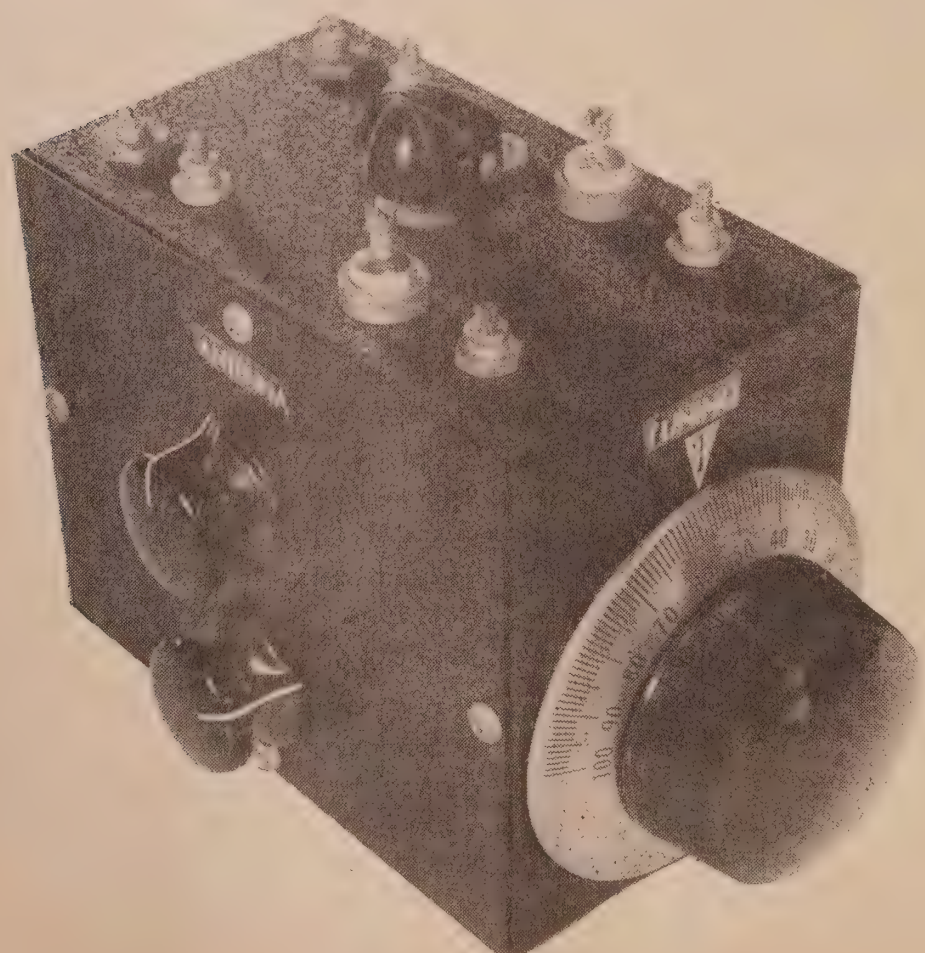
This converter covers the 10, 20, 40 and 75-meter phone bands. It may be made to cover 15 meters if one of the above bands is omitted. It is designed for good performance with a minimum of components and very low power drain.

A 6BE6 pentagrid converter serves as the mixer and oscillator. No. r-f stage is used, since the combination of the high *Q* mobile whip antenna and a 1500 kc. intermediate frequency reduces image response to an exceedingly low value. A variation of the popular *R9-er* input circuit, in which both the coupling and loading condensers are variable is used for matching the antenna to the 6BE6 input circuit. This circuit also eliminates the switching and adjustment of individual antenna coils. To provide a good match to the input impedance of an automobile receiver a slug tuned broadcast band antenna coil with a high impedance primary is used in reverse. The plate voltage of the 6BE6 is fed through the normal secondary of this coil (tuned to 1500 kc.) and the normal primary is used to couple to the antenna input of the auto receiver.

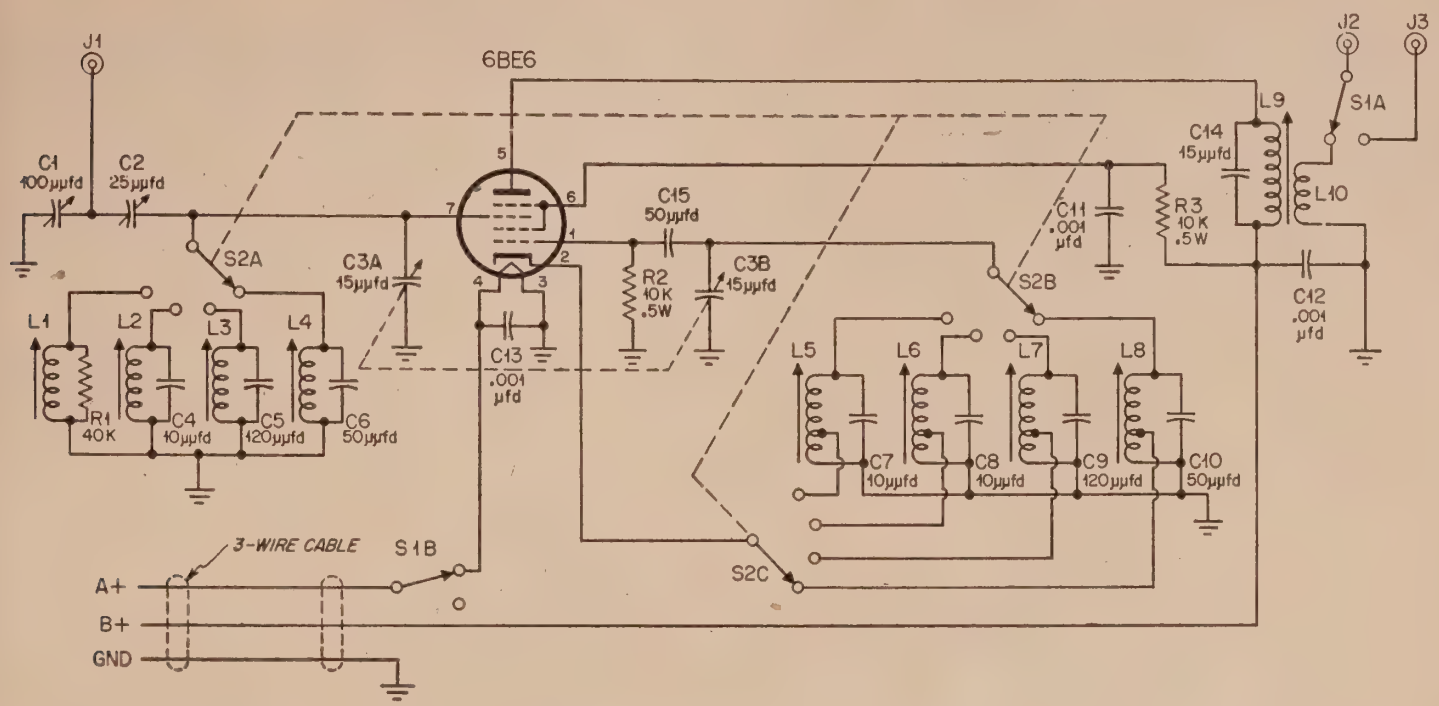
To improve oscillator-mixer stability on 10 meters a 40,000-ohm ½ watt resistor *R1* is connected across *L1*. A single deck rotary switch *S2* switches the grid and oscillator coils of the 6BE6 tube as well as the cathode tap for the 6BE6. A single-pole double-throw switch *S1* disconnects the converter from the antenna circuit and connects the broadcast antenna to the car receiver. This switch also turns off the filament of the 6BE6 when the converter is not in use. The complete schematic is shown in *Fig. 3-5-A*.

Construction

The converter is housed in a 3″ x 4″ x 5″ utility box that has removable sides *(Bud No. CU-728)*. All parts are mounted within the main portion of the box with the exception of condensers *C1* and *C2* which are mounted on



This one tube converter uses a 6BE6 and features band switching. The slugs for adjusting the tuning ranges are along the top of the cabinet. The band switch knob is mounted in the center top panel of the box.



the left cover plate of the box. Switch *S1* is mounted on the back wall of the box, as is the rubber grommet for the power cable. A *National type AM* vernier dial is mounted on the front of the box and drives the dual condenser *C3*. This condenser is bolted to the bottom of the box in line with the AM dial shaft and raised to the proper height by metal spacers. Bandswitch *S2* is mounted in the top center of the box.

The socket for the 6BE6 is the type with a metal center bushing *(Eby No. 9736)* to which is soldered a 6-32 threaded mounting stud about one inch long. This stud may be cut from a long 6-32 screw. The socket shield and *pin No. 3* are grounded to the stud. *Pin No. 1* is connected to *pin No. 3* through a 1/3 watt, 10,000 ohm resistor *R2*. *Pins No. 6* and *No. 4* are bypassed to the stud by .001 μfd. Ceramicon condensers. Three-inch lengths of insulated wire are soldered to *pins 2, 4, 5, 6* and *7*. These lengths will be trimmed and connected to other components after the socket assembly is mounted in place. This completes the socket assembly and it is ready to be mounted in an inverted position from the top of the box, just to the right of the band change switch, allowing enough room so that the tube will clear both the switch and the side panel of the box. The mounting stud should make good electrical connection to the box as it serves as a ground return for several circuits. This special socket assembly is shown in *Fig. 3-5-B*.

Coils *L1* and *L5* may be wound on *National XR-50* forms, or they may be manufactured units. If the *XR-50* form is used, the "ground" end of the coil should be nearest the mounting stud and may be grounded to the lug under the mounting bolt. Be sure the stud makes a good ground connection to the metal box.

Coils *L6, L7* and *L8* come with an insulated terminal bushing. These bushings are removed to conserve space. After unsoldering the terminal leads the bushings may be easily twisted off. New terminals are made of No. 18 bare wire and are secured through small holes drilled in the phenolic coil forms. The coil leads are soldered to these new terminals. The coils are all mounted to the top of the box with the slug adjustment screws protruding through the top of the box. The oscillator coils *(L5* through *L8)* are in a row to the right of the bandswitch and the detector coils *(L1* through *L4)* similarly mounted to the left of the bandswitch. The 75-meter coils *(L4, L8)* are mounted in the two rear positions, the 40-meter coils *(L3, L7)* are

C1—100 μμfd., variable, Bud LC-1646
C2—25 μμfd., variable, Bud LC-1642
C3A-B—15-15 μμfd., variable, Bud
C4, C7, C8—10 μμfd., ceramicon, Erie GP1K-100
C5, C9—120 μμfd., ceramicon, Erie GP2K-121
C6, C10—50 μμfd., ceramicon, Erie GP1K-500
C11, C12, C13—0.001 μfd., ceramicon, Erie 800-001
C14—15 μμfd., ceramicon, Erie GP1K-150
L1—8 turns, #16 spaced wire diameter on National XR-50 form
L2, L3—Meissner #14-1064 coil (5.3-16.5 Mc.)
L4—Meissner #14-1061 coil (1.7-5.3 Mc.)
L5—9 turns #16 spaced wire diameter on National XR-50 (Tap at 2 turns)
L6, L7—Meissner #14-1066 coil (5.3-16.5 Mc.)
L8—Meissner #14-1063 coil (1.7-5.3 Mc.)
L9, L0—BC antenna coil (Meissner 14-1056).
P1, P2, P3—Jacks, ICA #2378
R1—40,000 ohms, 1/3w.
R2, R3—10,000 ohms, 1/2w.
S1—D.p.d.t. toggle switch
S2—3-pole, 4-position, single deck rotary, Mallory 3134J
(Note: For 21-Mc band operation place a 25 μμfd. ceramicon across L1 and L5. These coils will tune to 15 meters.)

Fig. 3-5-A. Wiring schematic and parts list of the one tube bandswitching converter.

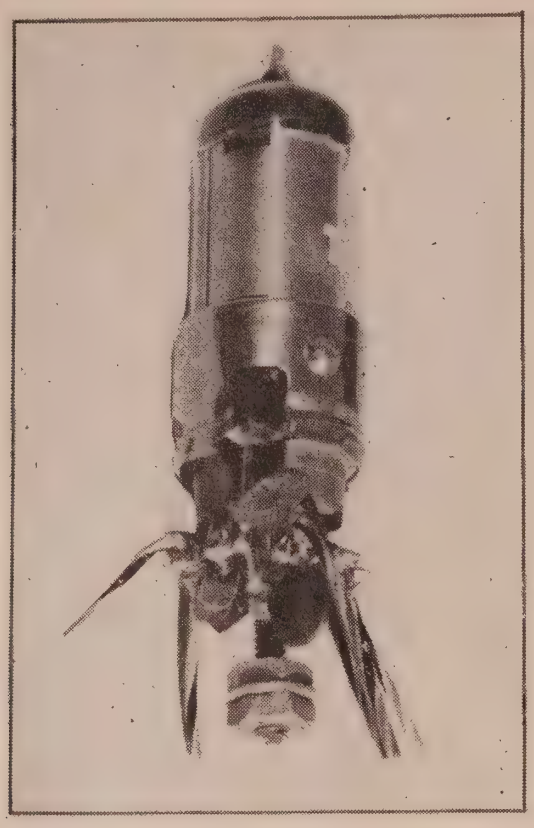


Fig. 3-5-B. The socket for the 6BE6 is modified according to the text to provide a mounting stud. This shows the finished socket prior to mounting in the converter with R2, C11 and C13 soldered in place.

next, the 20-meter coils *(L2, L6)* are in front of the bandswitch, and the 10-meter coils *(L1, L5)* are at the front of the box *(Fig. 3-5-C)*.

The output coil, *L9-10,* is mounted with the adjusting screw protruding from the back of the box. It is mounted near the top, just clearing the 75-meter coils. The toggle switch *S1* is mounted just below the output coil. The input and output antenna jacks are mounted one on each side of switch *S1*. The cable hole for the power leads is drilled near the bottom of the back edge. The 25 $\mu\mu$fd. midget variable condenser *C2* is mounted by means of the attached right angle bracket to the bottom of the box on the left side, positioned so that its shaft can protrude through a 3/8" hole drilled in the left side plate of the box.

The 100 $\mu\mu$fd. midget variable condenser *C1* is also mounted on the left plate of the box directly above *C2,* making sure that it will clear the coils and also *C3* when this side of the box is mounted in place. Make sure the side of the box makes a good ground connection to the box when the two pieces are fastened together. This completes the main assembly *(Fig. 3-5-D)*.

The bandswitch and coils are wired first. Be sure to position the switch to obtain the shortest possible leads to the coils. The wired socket is next mounted in place and the five leads from it are cut to length and soldered in place. Condensers *C4* through *C10* are installed. *C6, R3, R4* and *R1* are connected. The components on the left side plate are connected with flexible leads and the side plate is fastened to the box. The remaining connections are now made.

Test and Alignment

If a grid dip oscillator is available it will greatly facilitate alignment of the converter. The following steps are taken:

1. Align the output circuit *L9-10 to* 1500 kc.
2. Set *C3* (the main tuning condenser) near maximum capacity and set the bandswitch to 10 meters.
3. Adjust the slug of coil *L5* to resonate the coil to 29.5 Mc. Set *C1* and *C2* to mid-capacity and adjust slug of *L1* to resonate to 28.0 Mc.
4. Leaving *C3, C2* and *C1* set as above, change the bandswitch to 20 meters.
5. Adjust *L6* to 15.5 Mc., adjust *L2* to 14.0 Mc.
6. Change bandswitch to 40 meters.
7. Adjust *L7* to 8.5 Mc., adjust *L3* to 7.0 Mc.
8. Change bandswitch to 80 meters.
9. Adjust *L8* to 5.3 Mc., adjust *L4* to 3.9 Mc.

If a grid dip oscillator is not available the oscillator frequencies *(L5-L8)* can be set up by applying power to the converter and listening for the oscillator on a nearby receiver. The detector coils *(L1-L4)* can be then peaked on received amateur signals in the proper band. The antenna network condensers *C1* and *C2* are adjusted for best operation with the particular antenna in use at the time. *C2* can also be detuned when receiving strong local signals to prevent receiver blocking.

The bandspread on the 75-meter phone band is about 45 dial divisions. The 20-meter band occupies about 20 dial divisions, and if the inductance slug of *L6* is adjusted so that 14.0 Mc. is received with the tuning condenser *C3* at near maximum capacity the 15 Mc. short

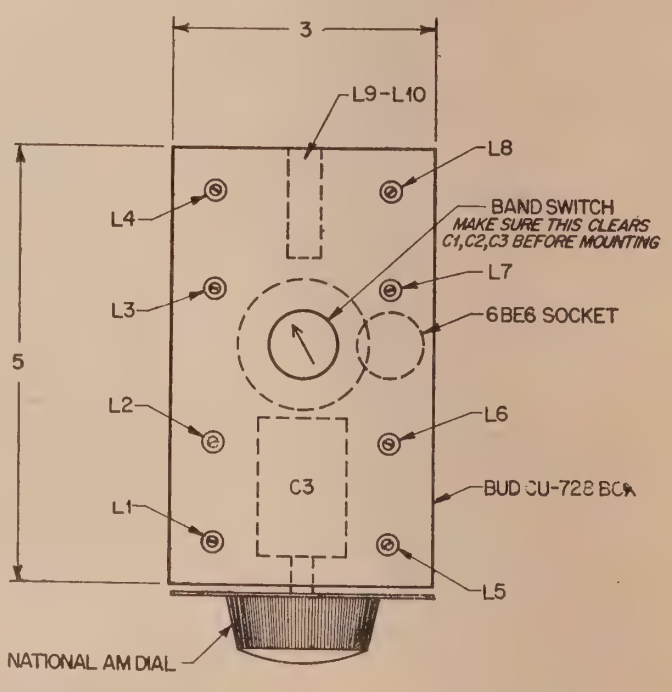


Fig. 3-5-C. This is a top view of the chassis-box. All of the tuning adjustments can be made before installation in the automobile.

wave broadcast band may also be covered. Bandspread on 10 meters is about 30 divisions and the 11-meter band may also be covered without slug readjustment.

3.6—Two Tube Plug-in Coil Converter

This simple converter is designed for operation on any amateur band from 10 to 80 meters. It uses plug-in coils for economy, since the coils for the most desired band may be wound at first, leaving the others to be completed at a later date. The converter uses a 6AK5 tuned r-f stage, and a 6BA7 oscillator-converter tube. The tuned grid circuit of the 6AK5 is inductively coupled to the tuned whip antenna of the mobile installation. The plate circuit of the 6AK5 is broadly tuned to the middle of the amateur band and loaded by *R2,* the grid resistor of the 6BA7. This circuit is peaked for optimum results in the middle of the particular band in use and then may be left alone.

The oscillator section of the 6BA7 is high *C* for best stability. The feedback voltage is obtained from a dividing network formed by *C6* and *C7,* the oscillator padding condensers. This particular circuit requires no cathode tap on the oscillator coil, simplifying the construction of the coils.

The plate circuit of the 6BA7 is tuned to 1500 kc., and has a low impedance output link, *L5,* to match the input of the average automobile broadcast receiver. The output transformer is made from a slug-tuned miniaturized inductance measuring less than one inch in length. (See *Fig. 3-6-E*)

Since many receivers operate with a plate potential as low as 120 volts, this converter is designed to also operate at that voltage. This is a distinct advantage, as screen dropping resistors and by-pass condensers may be omitted. The screens are connected directly to the B plus line and thus utilize the same B plus by-pass condensers. This greatly simplifies the construction of the converter. Both the 6AK5 and the 6BA7 will deliver top performance at a plate potential of 120 volts.

An "off-on" switch is incorporated in the unit, which switches the converter filaments, and at the same time connects the broadcast receiver either to the converter or to the usual car antenna. Three jacks are provided on the converter: one for the high frequency antenna, one for the auto radio antenna, and one for the output of the converter.

The power requirements of the converter are 120 volts at 25 milliamperes.

Construction

A photograph of the converter is shown in *Fig. 3-6-A.* On the left side of the unit are the three plug-in coils, and directly above the coils are the two tubes, the 6AK5 in front, and the 6BA7 in the rear. The front coil is the 6AK5 grid coil, *L1;* the center coil is the 6AK5 plate coil, *L2;* and the rear coil is the 6BA7 oscillator coil, *L3.*

The tuning dial is coupled by a short extension shaft visible in *Fig. 3-6-B* to *C12,* the main tuning condenser. Directly to the right of the tuning dial is *C1,* the r-f trimming condenser. Mounted on the right side of the box are the three antenna jacks and the "off-on" switch. On the rear of the box is the power receptacle.

The unit is built in a small aluminum utility box, measuring 3″ x 4″ x 5″. Before any work is done on the box, use paint cleaner on the edges of the box and the rims of the sides to make sure the two removable sides make good electrical contact to the main body of the box.

Figure 3-6-C shows the drilling dimensions. The three shielded coils plug into standard octal tube sockets. These sockets are mounted in a row along the bottom edge of the box, leaving enough clearance between the sockets and the bottom to allow the self-tapping screws to be driven home without hitting the sockets. The coil sockets are mounted so that the key pin is to the *rear* of the box. The 6AK5 socket is mounted with *pins 2* and *3* to the top of the box. The 6BA7 socket is mounted with *pins 1* and *9* to the top of the box.

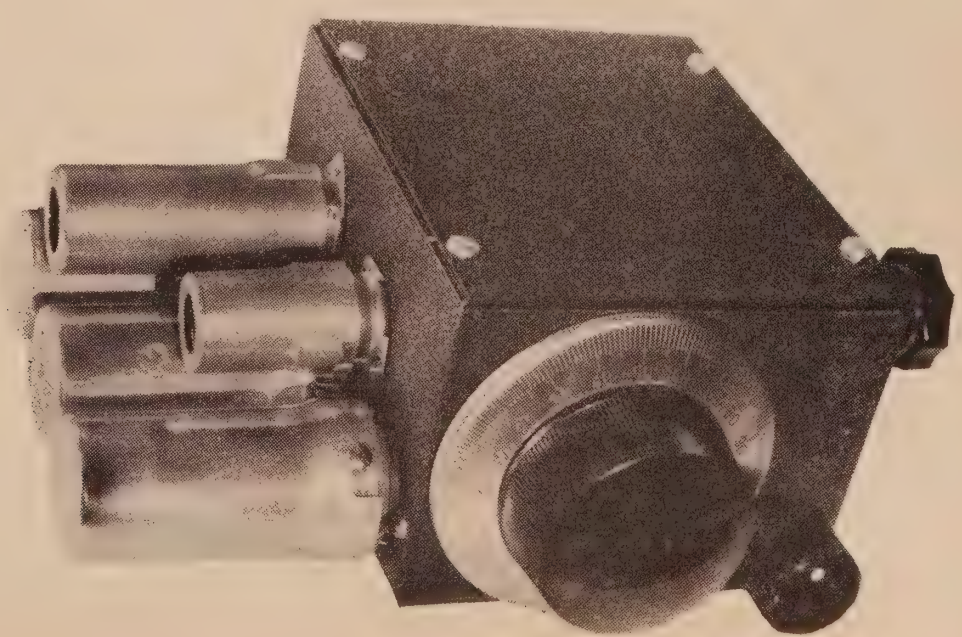
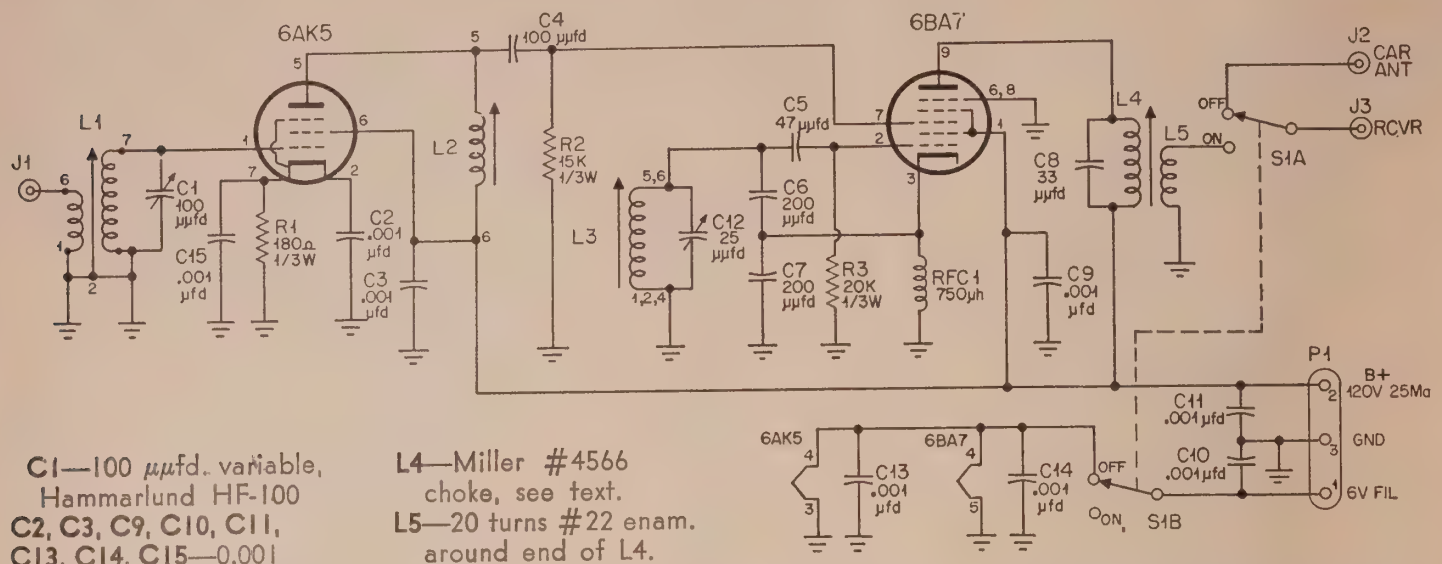


Fig. 3-6-A. Front view of the plug-in coil mobile converter. The lower right hand knob is for peaking the r-f stage. The knob visible on the right hand panel is the on/off switch.



C1—100 µµfd. variable, Hammarlund HF-100
C2, C3, C9, C10, C11, C13, C14, C15—0.001 µfd. ceramicon, Erie 801-001
C4—100 µµfd., Erie GP1K-101
C5—47 µµfd., silver mica, El-Menco #CM-15E-470J
C6, C7—200 µµfd., silver mica, El-Menco #CM-15E-201J.
C8—33 µµfd., Erie GP1K-330.
C12—25 µµfd., variable, Bud LC-1642.
L4—Miller #4566 choke, see text.
L5—20 turns #22 enam. around end of L4.
R1—180 ohms, 1/3w. (see text)
R2—15,000 ohms, 1/3w.
R3—20,000 ohms, 1/3w.
RFC1—750 uh., National R-33
J1, J2, J3—jacks, ICA #2378
S1—D.p.d.t. switch, Centralab #1462
P1—Socket, Cinch-Jones P303-FP
Dial—National AM

Fig. 3-6-D. Wiring schematic and parts list of the plug-in coil converter.

Condenser *C1* is a *Hammarlund HF-100*. This is just about the only make of condenser that will fit in the small area to the right of the tuning dial.

The main tuning condenser, *C12*, mounts on a 13/16" high metal post mounted to the bottom lid of the box. The rotor of the condenser is grounded to the post, and the condenser is driven through a flexible coupling and a short length of ¼" brass rod by the main tuning dial.

As shown in *Fig. 3-6-C*, three ¼" holes are drilled on the right side of the box. These holes are approximately in line with the tuning slugs of the three coils which project through the socket keys. A small screwdriver may be inserted in these holes to align the slugs while the coils are in the sockets and the converter is in operation.

Wiring

The complete schematic of the converter is shown in *Fig. 3-6-D*. Wire in this order:

1. *C2* between *pins 2* and *3 of* 6AK5. Ground *pin 3*. *C13* between *pins 3* and *4* of 6AK5. *C15* between *pin 7* of 6AK5 and ground lug of *L1* socket. *C3* between *pin 6 of* 6AK5 and ground lug of *L2* socket. *R2* between *pin 7* of 6BA7 socket and ground lug of *L2* socket. Connect *C14* from *pin 4* of 6BA7 to *pin 5*. Ground *pin 5*.
2. Wire *pin 1* of 6AK5 to *pin 7* of *L1* socket. Ground *pins 1* and *2* of *L1* socket to nearest socket lug. Wire *pin 6* of *L1* to *J1*. Wire *pin 7* of *L1* to stator of *C1*. Wire *pin 4* of 6AK5 to *pin 4* of 6BA7, thence to arm of *S1B*. The "on" contact of *S1B* to *pin 1* of *P1*. Install *C10, C11* on *pin 3* as ground.
3. Connect *C9* from *pin 1* of *6BA7* to ground lug under socket bolt.

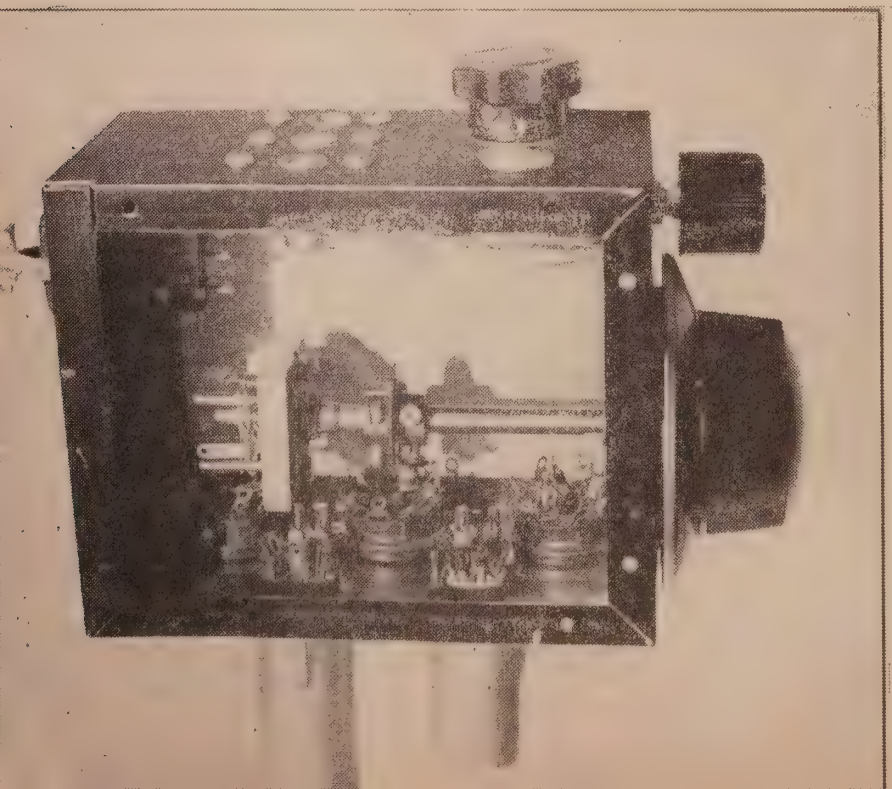


Fig. 3-6-B. Interior view of the converter before wiring.

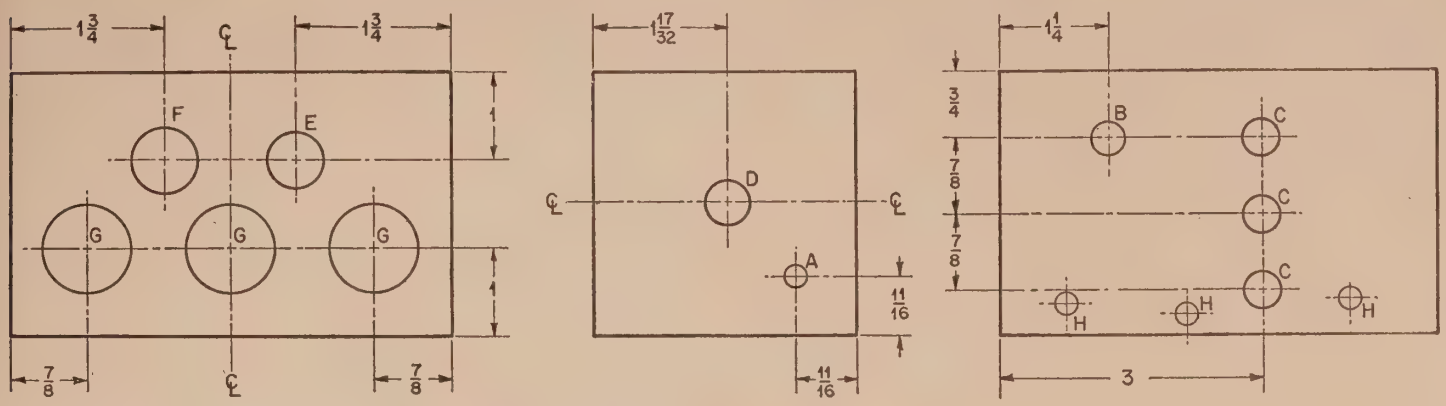


Fig. 3-6-C. Cabinet layout and drilling dimensions.

A HOLES 1/4 DIA
B HOLES 3/8 DIA
C HOLES 13/32 DIA
D HOLES 1/2 DIA
E HOLES 5/8 DIA
F HOLES 3/4 DIA
G HOLES 1 DIA
H HOLES 1/4 DIA DRILLED APPROXIMATELY AS SHOWN TO ALLOW SLUG TUNING.

Connect *C4* from *pin 5* of *6AK5* to *pin 7* of 6BA7. Ground *pins 1* and *2* of *L2* and *L3*. Connect *pin 5* of *L2* to *pin 5* of 6AK5. Connect *pin 6* of *L2* to *pin 6* of 6AK5. Connect *pin 6* of *L2* to *pin 1* of 6BA7, thence to *pin 2* of *P1*.

4. Connect *R3* from *pin 2* of 6BA7 to ground lug of *L3* socket. Jumper *pins 5* and *6* of *L3*. Connect *C5* from *pin 2* of 6BA7 to *pin 5* of *L3*. Connect *C7* from *pin 3* of 6BA7 to ground lug of *L3* socket. Connect *C6* from *pin 3* of 6BA7 to *pin 5* of *L3* socket. Connect *RFC* from *pin 3* of 6BA7 to *pin 4* of *L3* socket. Ground *pin 4* to *L3* socket lug. (*Pin 4* is used only as a tie-point.)
5. Connect *C8* directly across *L4* as shown in *Fig. 3-6-E*. Grid dip the combination to 1500 kc., by tuning the midget slug. It will tune with the slug almost all the way into the coil. Wind *L5* around the free end of *L4* and cover with nail polish and allow to dry. Leave about 8″ of leads on *L5*.
6. Mount *L4* between *pins 1* and *9* of 6BA7 using short lengths of solid, tinned copper wire. Ground one lead of *L5*, connect the other lead of *L5* to the "on" arm of S1A. Connect *J2*
7. Install *R1* from *pin 2* to *pin 3* of 6AK5. This is done last, so that in case of oscillation, *R1* may be removed and increased in value. Connect a 2″ lead to *pin 6* on *L3*. This will connect to *C12* when it is installed. Check all wiring. Check all parts.
8. Mount *C12* on the bottom plate and install it. Ground the rotor and connect the 2″ lead from *pin 6* of *L3* to

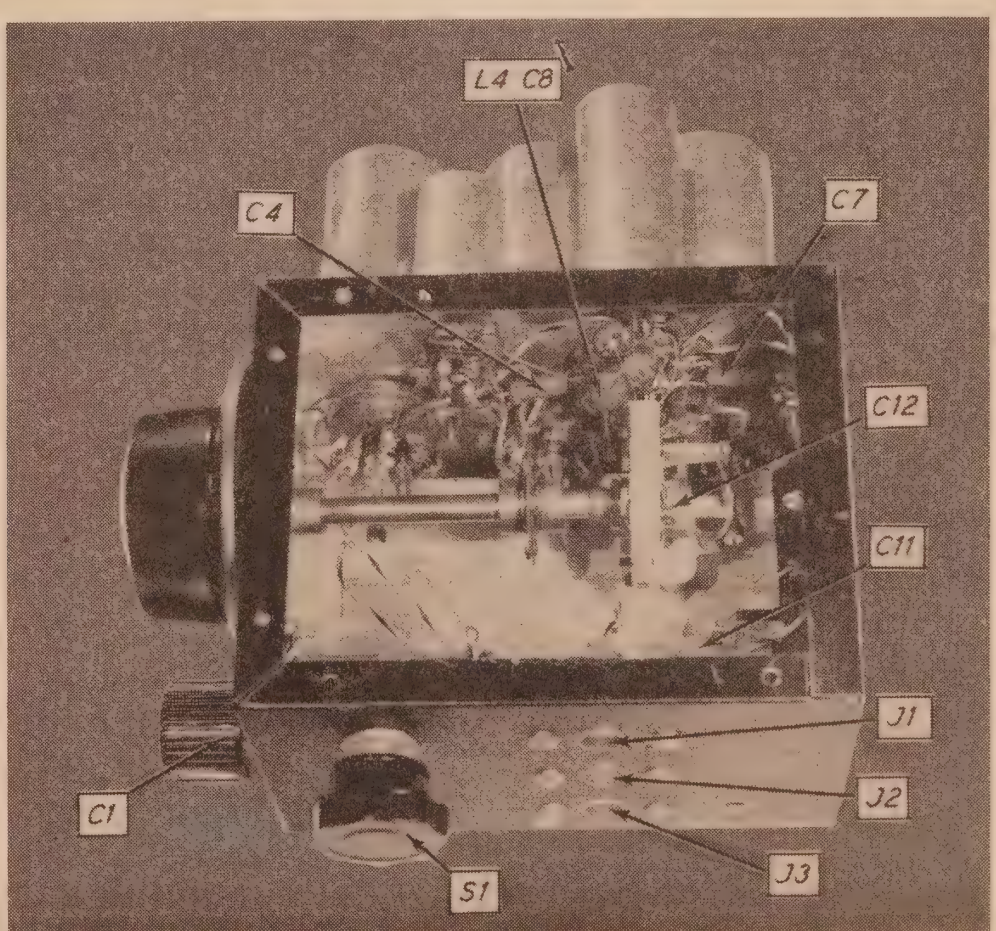


Fig. 3-6-F. This interior view shows the placement of the major components after wiring has been completed. If voltage regulation is desired, an OB2 regulator tube may be mounted next to the 6AK5 and connected from the B-plus line to ground. A 2000-ohm, 10-watt variable resistor should be placed between the OB2 and pin 2 of P1.

Table 3-6-A — Coil Data

80 Meters

L1—36 turns #28 DSC close wound. Antenna coil 15 turns #28 DSC around the ground end.
L2—112 turns #28 DSC, 1½" long with the last 30 turns scramble wound at the B plus end of the winding.
L3—26 turns #28 DSC close wound (tunes 5.3-5.5 Mc.).

40 Meters

L1—20 turns #28 DSC closewound. Antenna coil 8 turns #28 DSC around the ground end.
L2—55 turns #28 DSC close wound.
L3—Same as L3 above (tunes 5.5-5.8 Mc.).

20 Meters

L1—13 turns #28 DSC close wound. Antenna coil 5 turns #28 DSC around the ground end.
L2—25 turns #28 DSC closewound.
L3—7½ turns #28 DSC spaced the wire diameter (tunes 15.5-16 Mc.).

15 Meters

L1—10 turns #28 DSC closewound. Antenna coil 3 turns #28 DSC around ground end.
L2—15 turns #28 DSC closewound.
L3—5 turns #22 DSC spaced to ¼" long (tunes 19.5-20 Mc.).

10 Meters

L1—8 turns #28 DSC closewound. Antenna coil 3 turns #28 DSC around ground end.
L2—9 turns #28 DSC closewound.
L3—3-1/4 turns spaced to 1/4" using #22 DSC (tunes 26.5-28.2 Mc.).

the stator. Mount the coupling and extension drive shaft. This completes the wiring of the converter it should look similar to *Fig. 3-6-F.*

Table 3-6-A gives the complete coil information. The coils are wound on *Millen 74001* shielded, permability tuned coil forms. The coils should be wound close to the bottom end of the coil form, so that as the core is turned clockwise, the slug will slowly withdraw from the top end of the coil winding. In every case, the end of the winding nearest the coil pins is the "grid" end of the coil. The "ground" end is at the top of the coil form.

The bottom coil washer should be anchored with duco cement about ¼" above the base end. Small holes may be "drilled" in the lucite washers with a red-hot pin to serve as anchor points for the windings. After the coils are properly adjusted the windings should be given a thin coat of duco cement to prevent their shifting under vibration.

The oscillator coil, *L3,* has two pins in parallel for the "hot" lead to reduce the effects of socket contact resistance at 28 Mc. The oscillator operates 1500 kc. away from the received signal, and the oscillator tuning range is indicated in *Table 3-6-A.*

Testing and Alignment

Connect a 120-volt d-c power supply to the converter, and plug in a set of coils. (Let us use the 20-meter coils for an example.) Connect the converter, for test purposes, to the home station communications receiver. Turn on the converter. It should draw about 25 milliamperes of plate current at 120 volts. Leaving the output of the converter connected to the receiver, tune the receiver to the 15-Mc band and look for the signal from the oscillator of the 6BA7. It will be a steady S9 when you find it. It may be necessary to disconnect the receiver from the converter temporarily to prevent the oscillator signal from blocking the receiver. Tune *C12* from maximum to minimum capacity, adjusting the slug of *L3* so that the oscillator covers the range of 15.5 Mc. to 16.0 Mc.

Reconnect the output of the converter to the receiver, and tune it to 1500 kc. Since *L4-L5* has been grid dipped previously to 1500 kc., and tunes very broadly, it does not require readjustment.

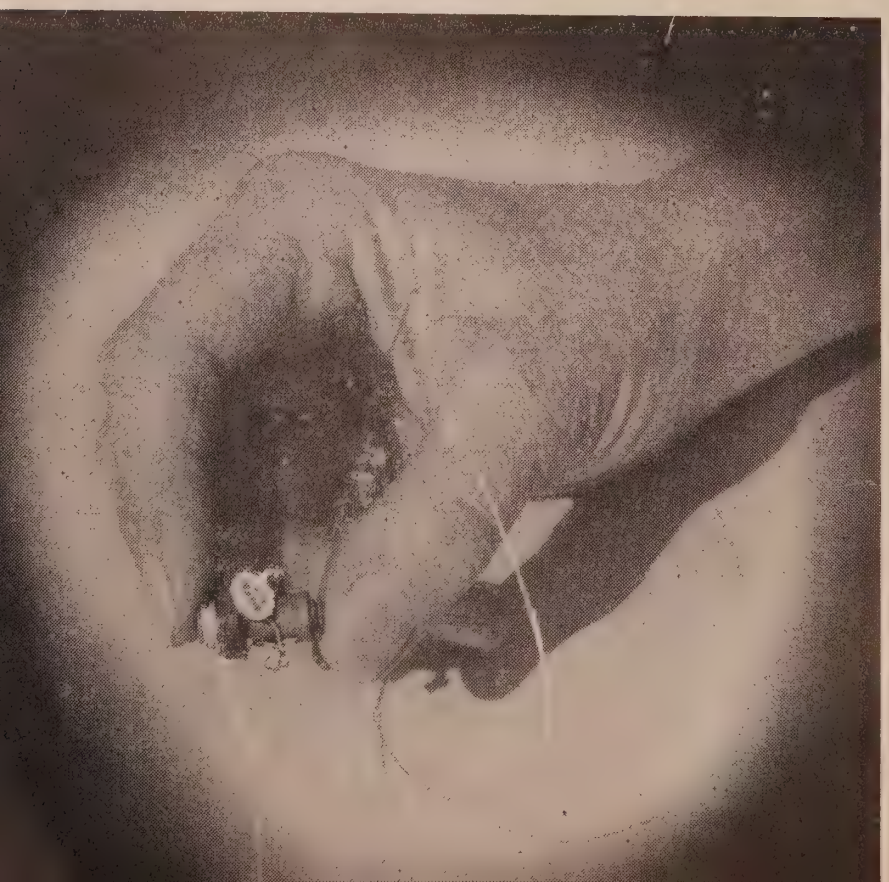


Fig. 3-6-E. This is the modified Miller #4566 choke which forms the minaturized output transformer L4/L5. Condenser C8 is connected across the L4 winding.

Connect an antenna to *J1* and look for amateur 20-meter phone signals, or use a signal generator tuned to 14.2 Mc. When signals are found, adjust the slug of *L1* until *C1* peaks the signal at about half capacity. The last adjustment is to tune the converter to the middle of the band and peak *L2* for maximum signal.

If there is any tendency for the 6AK5 stage to oscillate after it is loaded by the antenna, *R1* may be easily removed and replaced with a slightly higher value. With the 180 ohms indicated, the test model of the converter would just barely oscillate at 30 Mc. with no antenna connection. There was no sign of oscillation with the antenna connected to *J1*.

When all the tuned circuits of the converter are adjusted in the workshop, it may be placed in the automobile. The antenna lead from the car radio goes to *J3*, the broadcast antenna on the car to *J2* and the coaxial line from the transmitting antenna to *J1*.

If the power unit of the car receiver supplies more than 120 volts, a dropping resistor should be placed in the B plus lead to *pin 2* of *P1*. This resistor may be mounted on the back of the converter case. An adjustable 6000-ohm 25-watt resistor may be used *(IRC type 2½ DA)* for a supply up to 300 volts.

As with all converters of this type, a tuned antenna should be used. Since this is mandatory for the transmitter, it is no great problem.

3.7—Economical Single-Frequency Receiver

This receiver, designed and built by Basil Barbee W5FPJ is intended to do one particular job and do it as efficiently as possible: to monitor, 24 hours daily, a 10-meter 'phone calling frequency in order to intercept any calls from stations handling emergency traffic, mobiles passing through town, or one of the "gang" looking for a rag-chew. (Incidentally, there is no better way of getting apprised of a band-opening than by keeping such a squelch-equipped receiver going day and night.)

The receiver may be tuned to any frequency in or near the 10-meter band if the proper crystal frequency is chosen. By substituting other antenna, r.f. and multiplier coils, design information for which may be found in various handbooks, operation is possible on any band.

Front, rear and bottom views of the receiver are shown in *Figs. 3-7-A, B* and *C*.

General Design

Features considered essential in a receiver for this purpose are:

1. Single-frequency operation with no drift
2. Low power consumption
3. A "squelch" circuit
4. Battery-powered operation in emergencies
5. Adequate, but not excessive, selectivity
6. Good sensitivity and signal-to-noise ratio

Crystal control in this receiver assures accurate, driftless tuning to the desired frequency. Power consumption is about 7 watts, costing less than a penny a day to operate. Actually, some kilowatt-hour meters do not even register on such a light load! An unusual squelch circuit eliminates no-carrier noise which otherwise would become annoying in 24-hour operation. Power-supply hum, which might prove distracting in the middle of the night, is reduced below audibility by adequate filtering. The Jones connector on the rear of the chassis automatically disconnects the a-c power supply for battery operation when the battery cable *P3-P4* is substituted for the a-c cable *P1-P2*, making possible many hours of operation from a 1½ v. and 90 v. "Farm Pack" battery. Drain is about twice that of the average battery radio. The bandwidth at 10 times down is 14 kc., adequate to keep QRM out under present band conditions, while permitting a small amount of deviation from the intended frequency at the transmitter. Two 455-kc i-f amplifier stages and one r-f stage provide excellent sensitivity and signal-to-noise ratio.

Construction

The receiver is constructed on a 7 x 17 x 3 inch aluminum chassis and a 7 x 19 inch aluminum panel suitable for mounting in a relay rack. If rack-mounting is not desired, the same electrical arrangement may be used in other types of housing. The entire unit could probably be squeezed into a cabinet the size of a large cigar box, since with so little energy wasted in heat there is no ventilation problem, even in continuous operation. The sheet-aluminum shield from front to back of the underside of the chassis is necessary to prevent i-f oscillation. It is cut from an old broadcast transcription disk. The round shield cans for the coils *L1, L2, L3, L4,* and *L5* were removed from discarded

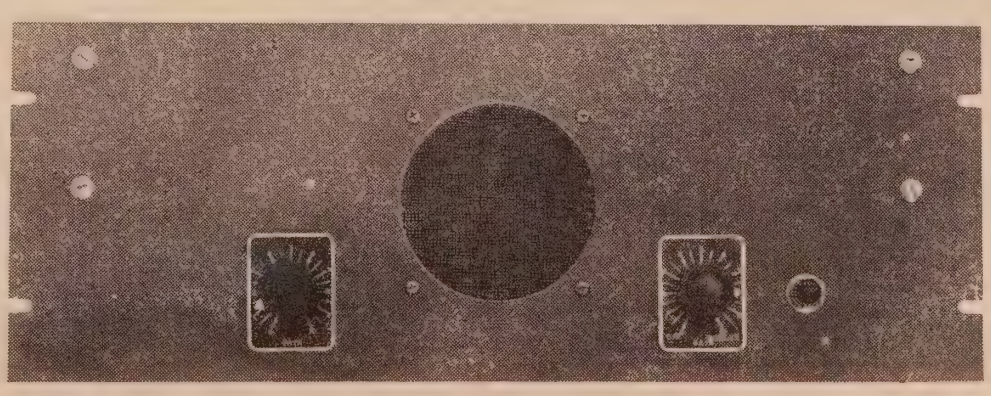


Fig. 3-7-A. This is a front panel view of a crystal controlled receiver for the home station at W5FPJ. It features the use of battery type tubes to maintain low cost continuous operation.

car-radio vibrators. Usually, old vibrators have an unsightly appearance from exposure of the drawn-zinc cans to the elements, but if after having been cut to size and drilled, the cans are buffed with *Tripoli* compound, wiped clean, and immediately sprayed or brushed with clear lacquer, their appearance will be quite acceptable.

The line-up consists of nine battery-type tubes with filaments in *parallel* (see *Fig. 3-7-D*). Some may shy away from the use of battery tubes due to unfortunate experiences with "3-way" portables. Most difficulties with such sets stem from the series connection of the filaments. When operated in parallel, battery tubes have proven quite dependable. The r-f and 1st and 2nd i-f stages employ type 1U4 pentodes. The mixer, h-f oscillator-multiplier, and squelch oscillator stages employ 1R5's. 1U4's could be used in these stages (with different socket connections), but 1R5's, while consuming more "B" power, give far better results due to their higher transconductance. (Parts layout is shown in *Fig. 3-7-E.*) The 1st and 2nd audio stages use a 1U5 and a 3V4 respectively in a conventional circuit except for the screen voltage divider and the grid return circuit of the 1U5. The voltage divider is necessary to maintain sharp cutoff for good squelch action, while the grid return is made through the squelch circuit in order that the 1U5 may be cut off when no signal is being received.

A conventional series-valve noise limiter using a *Sylvania* 1N54 germanium diode is permanently built-in the receiver. It is essential that this crystal have a high back-resistance in order to be effective. It has been found that "general-purpose" crystal diodes such as the 1N34 and 1N48, with back resistance in the vicinity of 0.2 megohm, are not satisfactory with resistors of the usual values in the circuit. If all resistances were made low compared to the crystal back-resistance, limiting action would probably be good, but the load on the diode detector would be of too low resistance for good selectivity and gain.

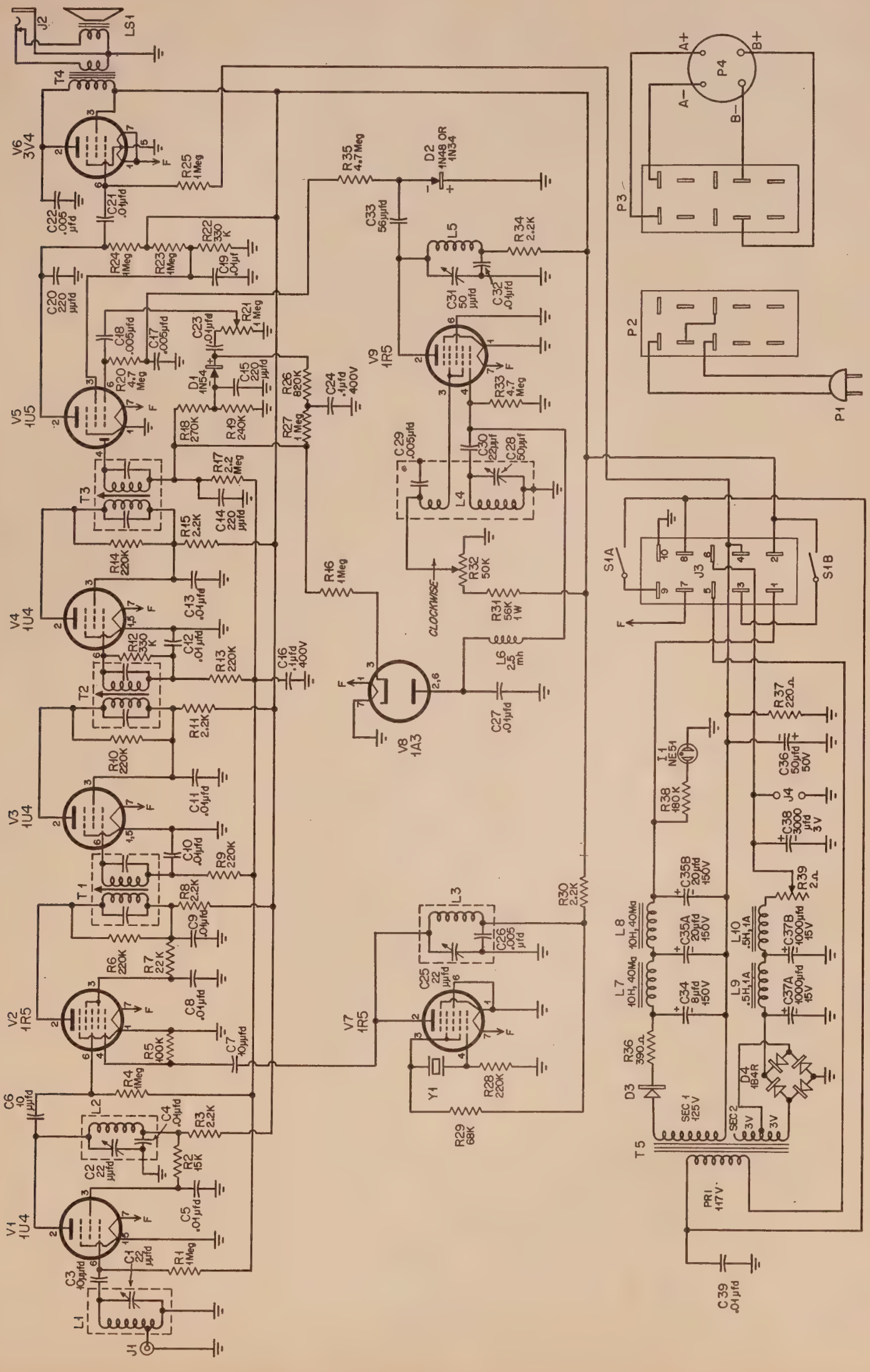
The Squelch Circuit

The most novel feature of this receiver is the squelch circuit, which is believed to be new and unique *(patent applied for)*. In any receiver designed to operate continuously on intermittent signals, squelch is a necessity to eliminate noise in the absence of any carrier. In its usual form, a squelch circuit consists essentially of a beyond cutoff negative bias applied to the grid of the 1st audio tube, and a d-c amplifier which, upon application of a-v-c voltage resulting from a received signal, or upon removal of a d-c voltage rectifier from no-carrier noise, reduces the beyond-cutoff bias to the normal operating value. This arrangement ordinarily requires that one or more cathodes be at other than ground potential. When using battery-type tubes with directly-heated filamentary cathodes, such an arrangement becomes impractical.

Accordingly, the circuit shown was devised, consisting of an electron-coupled oscillator-amplifier tube *V9*, operating on some frequency which will not interfere with the signals being

Fig. 3-7-D. Parts list and wiring schematic.

C1, C2, C25—22 μμfd., air trimmer, Bud LC-2077.
C3, C6, C7—10 μμfd., Centralab TCZ-10.
C4, C5, C8, C9, C10, C11, C12, C13, C19, C21, C23, C27, C32, C39—0.01 μfd., Centralab DD-103.
C14, C15, C20—220 μμfd., Centralab D6-221.
C16, C24—0.1 μfd., 400v., Mallory PT-401.
C17, C18, C22, C26, C29—0.005 μfd., Centralab DD-502.
C28, C31—50 μμfd., air trimmer, Bud LC-1644.
C30—22 μμfd., Erie GPIK-220.
C33—56 μμfd., Erie GPIK-560.
C34—8 μfd., 150v., Mallory TC-41.
C35A-B—20/20 μfd., 150., Mallory TCD-45.
C36—50 μfd., 50v., Mallory TC-39.
C37A-B 1000/1000 μfd., 15v., Mallory WP-200.
C38—3000 μfd., 3v., Mallory WP-032.
D1—1N54 germanium diode.
D2—1N48 germanium diode.
D3—Selenium rectifier, Sarkes Tarzian #35.
D4—Copper sulphide rectifier, Mallory 1B4R.
I1—Neon lamp bulb, NE-51.
J1—Co-ax receptacle, SO-239.
J2—Closed circuit phone jack.
J3—Socket, Cinch-Jones P-310-AB.
L1, L2, L3—10 turns, 1/2" dia., 1/2" long. Only L1 is tapped at 1 1/2 turns.
L4 primary—13 turns, 1/2" dia., 1/4" long, on form with L5.
L4 secondary—26 turns, 1/2" dia., 1/2" long.
L5—26 turns, 1/2" dia., 1/2" long.
L6—2.5 mh., r-f choke.
L7, L8—10 h., 40 ma., Merit C-2976.
L9, L10—0.5 h., 1 amp., filter choke.
LS1—4" speaker.
P1—A-c male plug.
P2, P3—Cinch-Jones S-310-CCT.
P4—Ordinary "Farm-Pack" battery plug.
R1, R4, R16, R24, R25, R27—1.0 megohm, 1/2w.
R2—15,000 ohms, 1/2w.
R3, R8, R11, R15, R30, R34—2200 ohms, 1/2w.
R5—100,000 ohms, 1/2w.
R6, R9, R10, R13, R14, R28—220,000 ohms, 1/2w.
R7—22,000 ohms, 1/2w.
R12, R22—330,000 ohms, 1/2w.
R17—2.2 megohms, 1/2w.
R18—270,000 ohms, 1/2w.
R19—240,000 ohms, 1/2w.
R20, R33, R35—4.7 megohms, 1/2w.
R21—1.0-megohm volume control, Central B-69.
R26—820,000 ohms, 1/2w.
R29—68,000 ohms, 1/2w.
R31—56,000 ohms 1/2w.
R32—50,000-ohm potentiometer, Centralab B-31-S with switch.
R36—390 ohms, 1/2w.
R37—220 ohms, 1/2w.
R38—180,000 ohms, 1/2w.
R39—2-ohm rheostat, Centralab V-100.
S1A-B—D.p.s.t. switch on the R32 control.
T1, T2—Miniature 455-kc i-f transformer
T3—Miniature 455-kc i-f transformer
T4—Midget output audio transformer, 10,000 ohms to v.c.
T5—Power transformer Merit P-3046.
Y1—40-meter crystal see text.


J2
LS1
T4
V6
3V4
C22
.005
μfd
C21
.01μfd
R25
1Meg
R35
4.7Meg
D2
1N48 OR
1N34
C33
56μμfd
L5
R34
2.2K
C31
50
μμfd
C32
.01μfd
R24
1Meg
R23
1Meg
R22
330
K
C19
.01μf
C20
220
μμfd
C18
.005μfd
C17
.005μfd
C23
.01μfd
R21
1 Meg
V9
1R5
R33
4.7
Meg
V5
1U5
D1
1N54
C15
220
μμfd
R26
820K
C24
.1μfd
400V
R18
270K
R19
240K
R27
1 Meg
C29
.005μfd
C30
22μμf
C28
50μμf
L4
R17
2.2
Meg
T3
C14
220
μμfd
R15
2.2K
R14
220K
R16
1Meg
R32
50K
CLOCKWISE
R31
56K
1W
V4
1U4
C13
.01μfd
R12
330
K
C12
.01μfd
L6
2.5
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C27
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R13
220K
C16
.1μfd
400V
T2
V8
1A3
R11
2.2K
R10
220K
V3
1U4
C11
.01μfd
C10
.01μfd
R9
220K
T1
R8
2.2K
C9
.01μfd
L3
R30
2.2K
C26
.005
μfd
C25
22
μμfd
R6
220K
R7
22K
V2
1R5
C8
.01μfd
C7
.01μfd
R5
100K
V7
1R5
Y1
R28
220K
R4
Meg
C6
10
μμfd
L2
C4
.01μfd
R3
2.2K
R29
68K
C2
22
μμfd
R2
15K
V1
1U4
C5
.01μfd
C1
22
μμfd
R1
1Meg
C3
.01μfd
L1
J1
P4
A+
B+
A−
B−
P3
P2
P1
S1A
S1B
J3
F
I1
NE51
R38
180K
C36
50μfd
50V
J4
C38
3000
μfd
3V
R37
220Ω
C35B
20μfd
150V
R39
2Ω
L8
10H, 40Ma
L10
.5H, 1A
C35A
20μfd
150V
C37B
1000μfd
15V
L7
10H, 40Ma
C34
8μfd
150V
L9
.5H, 1A
C37A
1000μfd
15V
R36
390Ω
D3
D4
1B4R
T5
SEC 1
125V
SEC 2
3V
3V
PRI
117V
C39
.01μfd

received (about 9 Mc. in this case, so that the harmonics will straddle the tuning range of the front end), a rectifier *D2* to make d-c control bias from the amplifier output, and a diode valve or "gate" *V8* to permit control of the oscillator by the a-v-c voltage.

In operation, the screen (oscillator plate) voltage is adjusted with the squelch control *R32* set so that oscillation begins and is barely sustained. This weak oscillation is amplified in the same tube and appears as several volts of r.f. in the plate circuit, which is tuned to the same frequency as the oscillator circuit. The 1N48 Germanium diode *D2* rectifies this r-f voltage, producing a negative d-c voltage which, after filtering by *R35* and *C17*, and to a lesser degree by *R20* and *C18*, is applied to the control grid of the 1st audio tube, cutting off this tube's plate current and silencing the receiver. When a signal is received, a negative voltage on the a-v-c line is produced by the action of the diode detector. As soon as this voltage exceeds the oscillator's own grid-leak bias (a fraction of a volt), the diode *V8* conducts, making the oscillator grid more negative, thus causing oscillation to cease. Since there is no longer any oscillator output voltage to amplify, the amplifier portion of the tube ceases to deliver voltage to the rectifier *D2*. The rectifier can no longer deliver d-c bias, the grid of the 1U5 returns to normal operating potential, and the receiver "comes alive." Operating bias for the 1U5 grid is derived from contact-potential drop in the two 4.7 megohm resistors *R20* and *R35*. Due to the comparatively low back-resistance of the diode *D2*, it serves as the ground-return for this circuit, through which the condensers *C17, C18,* and *C33* discharge when cutoff bias is removed. Had a thermionic diode tube been used here, then a resistor would have been required across the diode. Otherwise, assuming no leakage in condensers or elsewhere, the cutoff bias would remain on the 1st audio grid indefinitely after the diode *D2* had ceased to rectify.

The purpose of the 1A3 diode *V8* is to permit the negative a-v-c voltage to contribute to the grid bias of the oscillator in order to stop its oscillations, while preventing the oscillator's bias from backing up on to the a-v-c line and reducing the gain of the r-f and i-f stages. Here again, a crystal diode might have been used, at a saving of 0.21 watt of filament power, except for the fact that all crystals tried so far have had such low back-resistance as to partially or wholly defeat their purpose in this circuit. The low-pass filter *L6-C27* permits passage of d-c voltage to the oscillator grid while blocking r-f voltage which, originating at the oscillator, would otherwise be rectified by the diode and appear as positive d-c on the a-v-c line.

Audio and Power Circuits

A 4-inch PM loudspeaker is built in, to make the receiver entirely self-contained. In addition, a closed-circuit phone jack is provided on the rear of the chassis, into which an external speaker in another room may be plugged, since few operators spend 24 hours daily in the shack and some may want to monitor the calling frequency in other rooms of the house. Also, on the rear apron is a pair of pin jacks *J4*, for measuring filament voltage and a rheostat *R39* for adjusting it to the recommended value of 1.4 volts. Operating filament-type tubes at their proper voltage is conducive to long tube life.

All parts used in this receiver are readily available, many of them from the junk-box and surplus sources. The net cost of all parts including chassis and panel, if purchased new, would be approximately $65. Actually, only about $15 worth were bought new. Power-

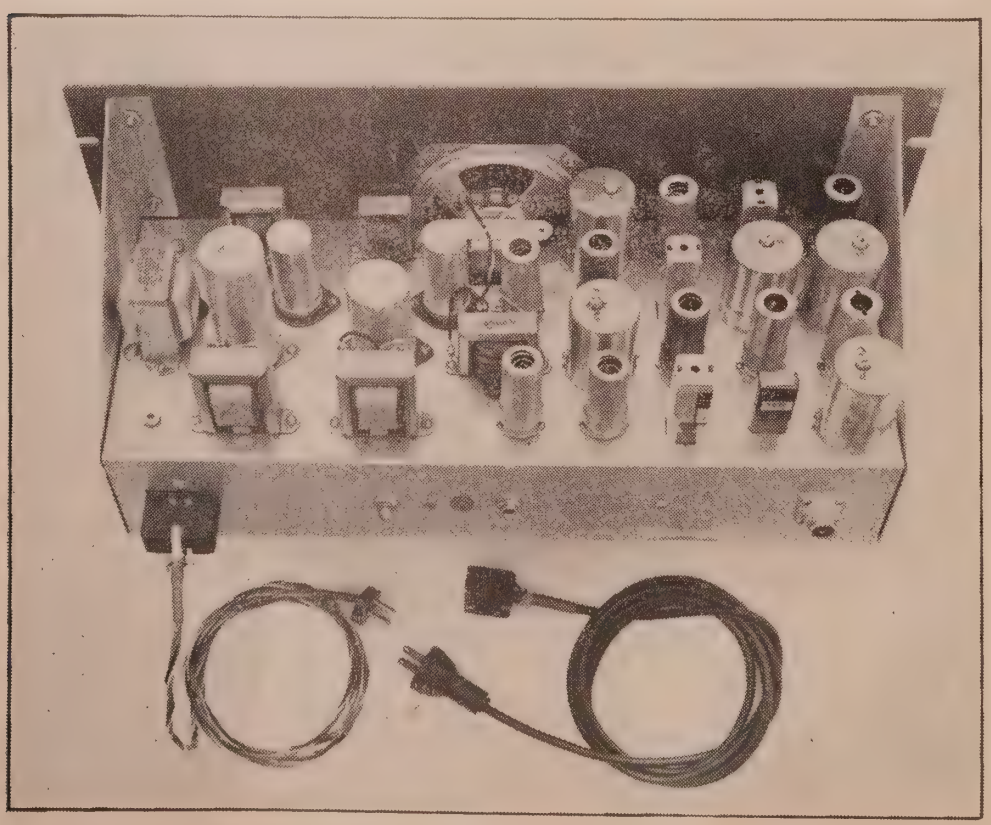


Fig. 3-7-B. The receiver is rack mounted with emphasis on good workmanship. Two power cables are provided so that the equipment may be operated from either a-c lines or from a battery pack.

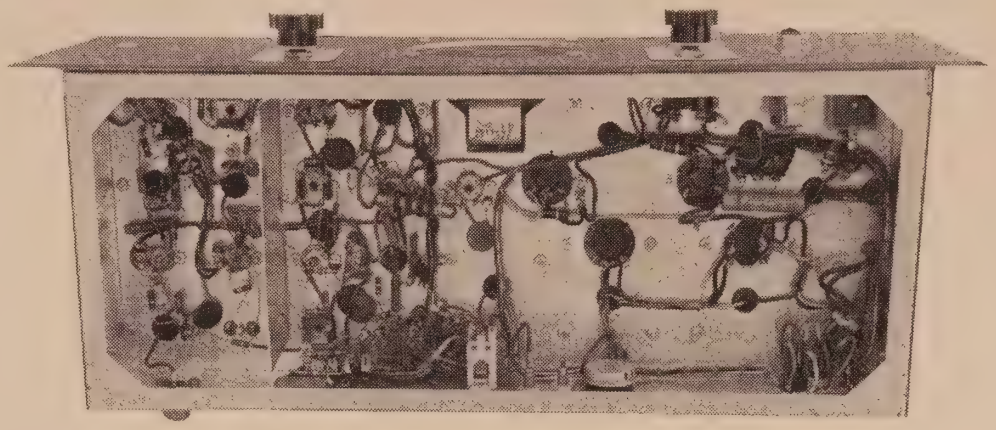


Fig. 3-7-C. Looking under chassis of the fixed frequency receiver. The two front panel controls are for volume and squelch.

supply components were salvaged from old battery-eliminators. All variable air trimmers were procured from surplus, while all r-f coils were hand-wound on ½" polystyrene tubing.

Alignment of the Receiver

No trouble in alignment should be experienced by the constructor familiar with superhet receivers. Assume, for example, that the receiver is to be tuned to 29,640 kc. First, a quartz crystal should be selected for *Y1* whose frequency is within a few kc. of any sub-multiple of either 29,185 or 30,095 kc. (29,640 ± 455). Tracking in a fixed-frequency receiver is no problem, and the oscillator frequency may be either above or below the signal frequency. A crystal whose frequency is 7296.25 kc. or ¼ of 29,185 kc., may be used. But suppose that the nearest crystal obtainable is 7295? That will be perfectly acceptable. The 4th harmonic is 29,180 kc. Subtract this from 29,640, and it gives 460 kc., which must be the intermediate frequency if that crystal is to be used. The i-f stages, therefore, are aligned to peak at whatever frequency is the *difference* between 29,640 and any multiple of the crystal frequency, providing that difference is within the tuning range of the i-f transformers. Most i-f transformers of the type specified will cover the range of 440 to 475 kc. Having chosen a suitable crystal and aligned the i-f system to correspond to it, the rest of the procedure consists merely of peaking *C1, C2,* and *C25* at the signal frequency.

For the benefit of those who have not previously aligned crystal-controlled receivers, it is well to point out that a slight error in determining the crystal frequency or in the calibration of the signal generator used in aligning the i-f stages may result in a more or less serious misalignment, a condition which should be checked, and if necessary corrected, by an "on-the-air" alignment with a weak signal from a transmitter known to be on the desired frequency. In fact, even in the absence of a signal generator, the whole alignment process may be accomplished by on-the-air alignment, first with a strong signal of desired frequency, and then with progressively weaker and weaker signals of the same frequency.

Squelch Alignment

Alignment of the squelch circuit is easy, and need not be done over each time the front end is realigned for a new frequency, unless the new frequency should fall near a harmonic of the squelch oscillator. The squelch control is merely turned to full-squelch position (clockwise) so that the squelch oscillator is going full-strength. If a harmonic appears at or near the frequency to be received, the trimmer *C28* is turned one way or the other to shift the harmonic elsewhere. Then the plate circuit is tuned, by turning the trimmer *C31,* for maximum output as indicated by maximum negative d-c voltage at the grid of *V5,* or by minimum plate current in *V5.*

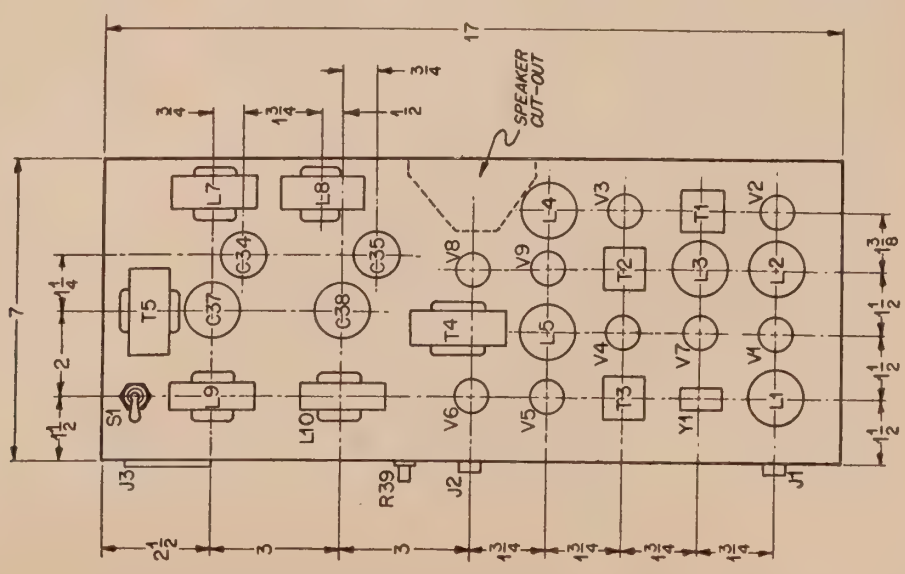
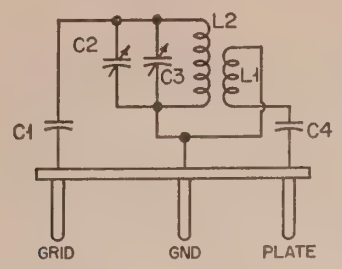


Fig. 3-7-E. Suggested chassis layout.



C1 – 250 μμfd CERAMIC, ERIE TYPE GP1K
C2 – 2-4 μμfd MIDGET VARIABLE CONDENSER, JOHNSON 160-102
C3 – 75 μμfd TRIMMER, ERIE NPO-333-500 FIXED CERAMICON PARALLELED WITH ERIE 557-5 CERAMIC TRIMMER
C4 – 250μμfd CERAMIC, ERIE TYPE GP1K

L1 – 7 TURNS # 26E, WOUND OVER L2, ABOUT 1" LONG
L2 – 15 TURNS # 26E, 3/4" LONG WOUND ON 1/2" DIA POLYSTYRENE COIL FORM. ADJUST TO TUNE TO 28 MC BAND WITH C2, C3.

Fig. 3-7-G. Wiring schematic of the adapter.

A "Rubber Crystal" Adapter

The transconductance of 1.4-volt tubes is not great enough to permit variations of more than a few kilocycles when the crystal is padded with shunt capacity.

Accordingly, a plug-in adapter was designed to be inserted in the crystal jack in place of the quartz crystal. This adapter will provide a frequency shift of plus or minus 60 kc. from the center frequency.

The adapter *(Fig. 3-7-H)* is built upon a small frame with a base area of 1½ x 1½ inches and a height of only 2 inches, exclusive of the tuning knob and base prongs. The circuit is an Armstrong with shunt feed in both grid and plate to convert the crystal oscillator into a high stability master oscillator working in the 20-meter range.

The rotor of the tuning control and one end of each coil are grounded. In order to make this ground connection, a banana jack was mounted, without insulation, on the chassis of the receiver on one side of the crystal socket. An extra banana plug is installed on the bottom of the plug-in unit. When the adapter is plugged into the crystal socket, a ground connection is automatically made to the circuit elements. If this plug and jack connection are mounted slightly off-center, it will be impossible to plug the adapter into the socket the wrong way.

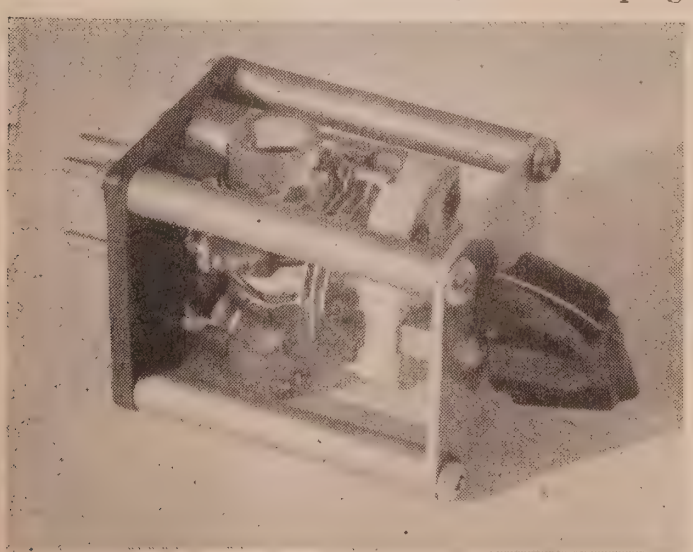


Fig. 3-7-H. The adapter may be easily constructed from a few parts in the junk box.

The circuit of the adapter is shown in *Fig. 3-7-G*. *C1* is the grid blocking condenser and *C4* the plate blocking condenser. *C2* is a small variable while *C3* is used for bandsetting.

The assembly is made very rigid by mounting all the components on the two end plates. The top end plate is made of soft aluminum and grounds the rotor of *C2* while shielding the condenser from hand capacity effects. The bottom plate is made of bakelite. Two-prongs are cut from 3/32" brazing rod and are ⅞" long. One end is threaded to fit a 4-40 bolt and the other is rounded to provide a close fit for the crystal jacks.

The two small coils are wound on a 1½-inch length of one-half inch diameter polystyrene tubing. *L2* is wound directly over *L1* to provide adequate coupling. The circuit is tuned to 20 meters and the second harmonic of the oscillator is used to eliminate frequency pulling. Any center frequency in the 10-meter band may be selected with *C3*.

Installation of the Receiver

Installation consists of plugging an antenna into the antenna jack, *J1*, and plugging one of the power cables into a convenient source of power. If desired, connections may be made to the transmitter changeover relay to silence the receiver during transmissions, though there is much doubt whether this is necessary. Once contact has been established, the station's regular general-coverage receiver will be used, and the calling-frequency receiver may be turned off. At the conclusion of a QSO, it may be turned back on and will be ready for operation with no warm-up delay and no warm-up drift.

In operation, the volume control is set to the desired volume, and the squelch control is set, in the absence of signals, to a point where the receiver is silent, even when vehicular traffic is heavy. Thereafter, any signal on the frequency to which the receiver is tuned, and strong enough to override the noise, will "open" or "break" the squelch and make itself heard. Since the installation of this receiver at W5FPJ, many DX stations have "broken the squelch" to signal the opening of the band, thus saving many fruitless revolutions of the dial of the standard communications receiver.

Best results, particularly on mobile signals, are obtained by operating this receiver on a non-directional antenna, such as a vertical ground-plane type.

3.8—The "Standard of Comparison"

The *Standard of Comparison* mobile receiver receiver was designed and built by Wilfred Scherer, W2AEF, and described in complete detail in the November, 1951, issue of *CQ Magazine*. Since the original description of this outstanding receiver is too long to be included in the *Mobile Handbook*, the readers is referred to the back issue of the magazine, copies of which may be obtained from the publisher.

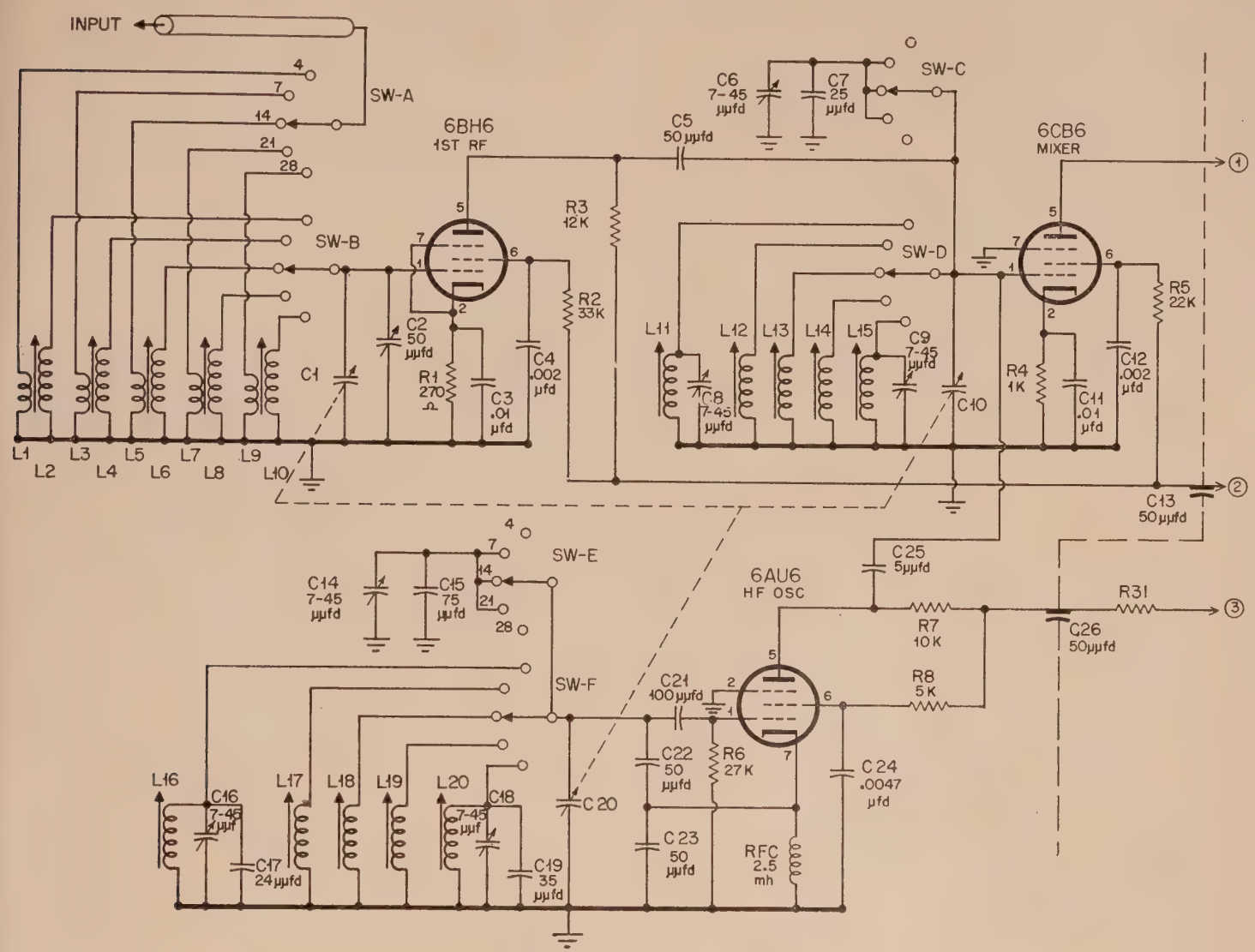


Fig. 3-8-B. Modified front end to cover the 15 and 40-meter bands.

The original receiver has proven to be so popular, that a short description is provided herewith to enable an owner of this receiver to modify it to cover the new 15 and 40-meter phone bands. The addition of the newly developed *TNS Noise Squelcher* is also described.

A Brief Description of the Original Receiver

The *Standard of Comparison* is a 9 tube double conversion superheterodyne receiver, covering the 2, 6, 10, 20 and 80-meter amateur bands. The receiver incorporates complete band switching, a tuned r-f stage and a built-in loud speaker. 6AK5 tubes are used as the r-f amplifier and mixer for high gain and low noise figure. An antenna compensating condenser, *C2,* is incorporated in the r-f stage to enable adjusting for various reflected antenna loads. A 6C4 is used in a Colpitts oscillator for maximum stability. The second mixer is a 6BE6, converting the 1488 kc. first i.f. to a lower frequency of 262 kc. for maximum selectivity. Two 6BJ6 tubes serve as i-f amplifiers at 262 kc. A 6AL5 acts as a detector and noise limiter, and a 6AV6 is used as the first audio stage. The speaker is driven by a single 6AQ5 output tube. The voltage supply to both the low and the high frequency oscillators is regulated by a OA2 voltage regulator.

Figure 3-8-A is a *corrected* circuit diagram of the original receiver.

C1, C10, C20—15 μμfd. per section. Defiance All Star Products Model C3, three gang. For C1 and C10 modify to one rotor and two stator plates. With slight change in layout the following may also be used: Bud LC-1846 three gang, or three single units similar to Bud LC-1641 ganged together with flexible couplings.
C2—50 μμfd., National PSE-50.
C3, C11—0.01 μfd., disc ceramic.
C4, C12—0.002 μfd., disc.
C5—50 μμfd., tubular ceramic.
C6, C8, C9—7-45 μμfd., ceramic.
C7—25 μμfd., tubular ceramic.
C13, C26—50 μμfd., ceramic feed thru higher value may be used).
C14, C16, C18—7-45 μμfd., ceramic, negative coefficient.
C15—75 μμfd., ceramicon, zero coefficient.
C17—24 μμfd., ceramicon, zero coefficient.
C19—35 μμfd., ceramicon, zero coefficient.
C21—100 μμfd., silver mica.
C22, C23—50 μμfd., silver mica.
C24—.0047 μfd., disc.
C25—5 μμfd., ceramic.
R1—270 ohms, 1/2w.
R2—33,000 ohms, 1/2w.
R3—12,000 ohms, 1/2w.
R4—1,000 ohms, 1/2w.
R5—22,000 ohms, 1/2w.
R6—27,000 ohms, 1/2w.
R7—10,000 ohms, 1/2w.
R8—5,000 ohms, 1/2w.
R31—2,000 ohms, 1/2w.
RFC—2.5 mh. choke.

The following corrections should be made to *Fig. 3* of the original article:

1. On the right hand chassis: Socket V3 should be at the front, and socket V1 at the rear.
2. The second hole from front (E) is 1-9/16" from the front edge.
3. Socket V2 is 2⅞" from the rear.
4. The three holes marked (E) should be ⅜" in diameter. They should be located 3/16" from the right edge of the chassis. The (F) holes should be moved accordingly.

The following correction should be made to *Fig. 5* of the original article:

1. Resistor *R12A* should be labelled *R15*. It is 2000 ohms.

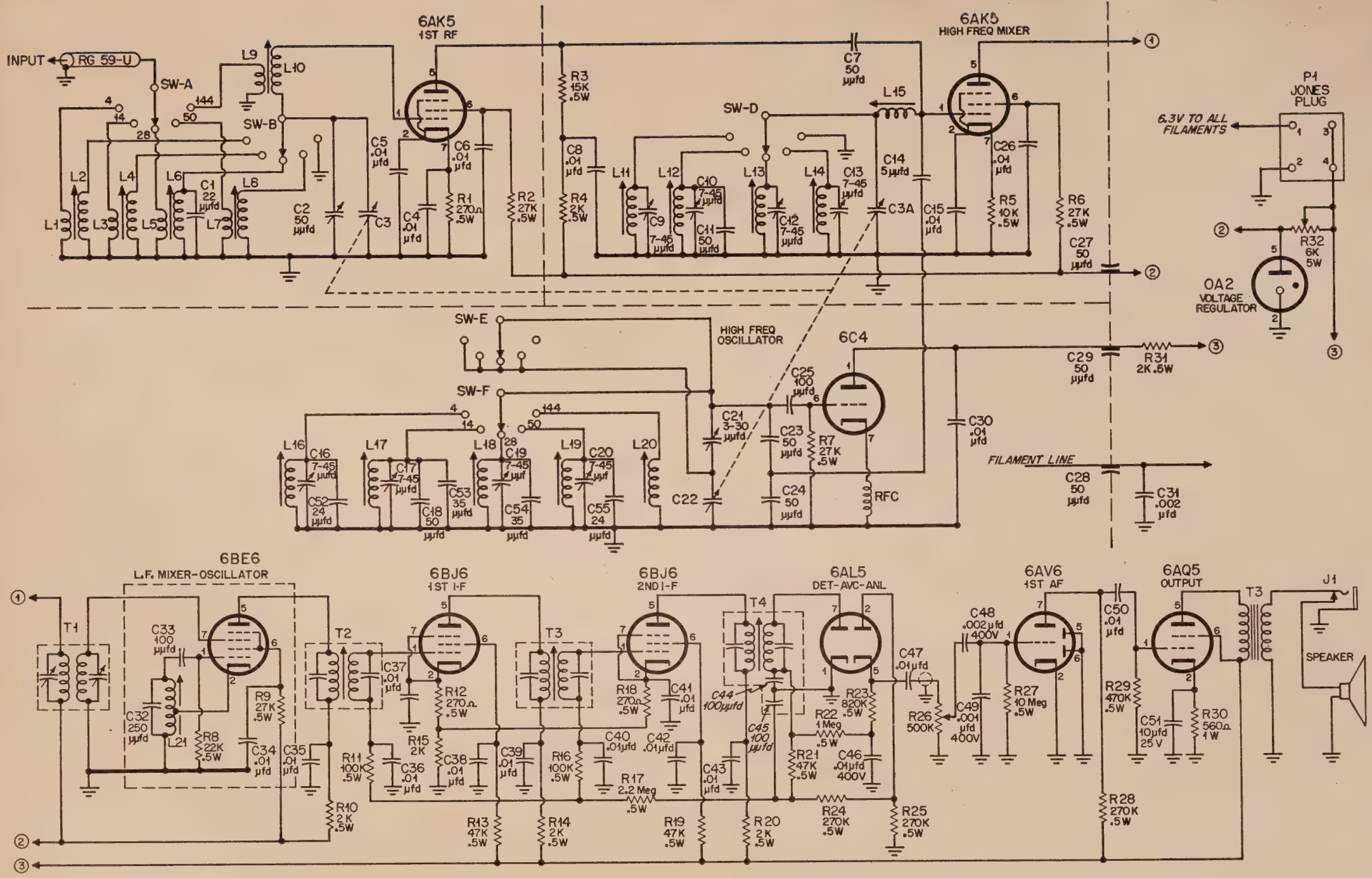
Modifying the Standard of Comparison Mobile Receiver for 10-15-20-40-75 Meter Bands

In order to provide space for the inclusion of the two extra lower frequency bands on the mobile receiver, it is necessary to eliminate the 2 and 6-meter bands.

The modified arrangement is shown in the circuit diagram *Fig. 3-8-B*. A 6BH6 may be used for the r-f amplifier instead of the 6AK5 providing higher gain with excellent noise figure. A 6CB6 may be used as a high gain mixer. Since the two highest frequency bands are eliminated, a 6AU6 replaces the 6C4 oscillator, and the oscillator is operated on the fundamental frequencies instead of on the harmonics. The

Fig. 3-8-A. Original receiver wiring schematic and parts list.

C1—22 μμfd., ceramic.
C2—50 μμfd., National PSE 50.
C3, C3A, C22—Use Bud LC1846 (adjust mechanical layout), or gang three Bud LC1641 units or National UM15 units with flexible cable.
C4, C5, C6, C8, C15, C26, C30, C34, C35, C36, C37, C38, C39, C40, C41, C42, C43, C47, C50—.01 μfd. disc ceramic.
C7, C11—50 μμfd. ceramic.
C9, C10, C12, C13—7-45 μμfd. ceramic.
C14—5 μfd. ceramic.
C16, C17, C19, C20—7-45 μμfd. ceramic, neg. temp. coef.
C18—50 μμfd, Mica.
C21—3-30 μμfd. ceramic, neg. temp. coef.
C23, C24—50 μμfd. silver mica.
C25, C33—100 μμf silver mica.
C27, C28, C29—50 μμfd. ceramic feedthru.
C31—.002 μfd. ceramic HyKap.
C32—250 μμf silver mica.
C44, C45—100 μμfd. part of T4.
C46—.01 μfd., 400-volt paper.
C48—.002 μfd., 400-volt paper.
C49—.001 μfd., 400-volt paper.
C51—10 μfd., 25-volt electrolytic.
C52, C55—24 μμfd., zero temp. coef.
C53, C54—35 μfd. zero temp. coef.
R1, R12, R18—270 ohms, ½w.
R2, R6, R7, R9—27,000 ohms, ½w.
R3—15,000 ohms, ½w.
R4, R10, R14, R20, R31—2,000 ohms, ½w.
R5—10,000 ohms, ½w.
R8—22,000 ohms, ½w.
R11, R16—100,000 ohms, ½w.
R13, R19, R21—47,00 ohms, ½w.
R15—200 ohms, ½w.
R17—2.2 meg., ½w.
R22—1 meg., ½w.
R23—820,000 ohms, ½w.
R24, R25, R28—270,000 ohms, ½w.
R26—500,000 ohms, miniature potentiometer.
R27—10 meg. ½w.
R29—470,000 ohms, ½w.
R30—560 ohms, 1w.
R32—6000 ohms, 5 watt, with slider.
J1—Single closed circuit jack.
P1—Jones plug, P304-AB.
RFC1—2.5 mh, National R100.
Spkr—Perm-O-Flux, 3", model 3A.
Sw—A, B, C, D, E, F—Ceramic Switch, 3 gang, each 2 circuits 5 positions. Mallory #181C or Centralab #2525.
T1—Stanwyk, 1st r.f. #SM129, 1500 kc.
T2, T3—Meissner, input #16-6752, 262 kc.
T4—Meissner, output #16-6754, 262 kc.
T5—Stancor, a.f. output #A 3 8 7 7, 5000 ohms to 4 ohm v.c.
L1—15 turns #28 enamel, scramble wound over bottom turns of L2 after first wrapping several layers of electrical Scotch tape around latter.
L2—4 Mc, 70 turns #32 enamel, close wound on CTC #LS3, ⅜" diameter slug tuned form.
L3—1 turn #20 plastic covered wound over bottom turns of L4.
L4—14 Mc, 12 turns #22 enamel close wound on CTC #LS5, ⅜" diameter ceramic slug tuned form.
L5—1 turn #20 plastic covered wound over bottom turn of L6.
L6—28 Mc, 10 turns #18 enamel close wound on CTC #LS6, ¼" diameter ceramic slug tuned form.
L7—1 turn #20 plastic covered wound over bottom turn of L8.
L8—50 Mc, 6 turns #18 enamel, close wound on CTC #LS6 form.
L9—1½ turns #20 plastic covered wound around middle of L10.
L10—144 Mc, 5 turns #16 space wound on CTC #LS6 form.
L11—4 Mc, same as L2.
L12—14 Mc, 10 turns #22 enamel close wound on CTC #LS5 form.
L13—28 Mc, 10 turns #18 enamel close wound on CTC #LS6 form.
L14—50 Mc, 4 turns #18 enamel space wound on CTC #LS6 form.
L15—144 Mc, 3 turns #18 enamel, wound on ¼" diameter polystyrene rod with 8/32 brass slug, winding length ½".
L16—4 Mc, 25 turns #32 enamel close wound on CTC #LS3 form.
L17—14 Mc, 15 turns #26 enamel close wound on CTC #LS5 form.
L18—28 Mc, 14 turns #26 enamel close wound on CTC #LS6 form.
L19—50 Mc, 6 turns #24 enamel space wound on CTC #LS6 form.
L20—144 Mc, 3 turns #22 enamel space wound on CTC #LS6 form.
L21—1750 kc, 63 turns #32 enamel close wound on CTC #LS4, ½" diameter slug tuned form, tapped at 11th turn from bottom.


INPUT
RG 59-U
SW-A
SW-B
SW-D
SW-E
SW-F
6AK5
1ST RF
6AK5
HIGH FREQ MIXER
HIGH FREQ OSCILLATOR
6C4
6BE6
L.F. MIXER-OSCILLATOR
6BJ6
1ST I-F
6BJ6
2ND I-F
6AL5
DET-AVC-ANL
6AV6
1ST AF
6AQ5
OUTPUT
P1
JONES PLUG
6.3V TO ALL FILAMENTS
0A2
VOLTAGE REGULATOR
FILAMENT LINE
RFC
SPEAKER
L1
L2
L3
L4
L5
L6
L7
L8
L9
L10
L11
L12
L13
L14
L15
L16
L17
L18
L19
L20
T1
T2
T3
T4
J1
C1 22 µµfd
C2 50 µµfd
C3
C4 .01 µfd
C5 .01 µfd
C6 .01 µfd
C7 50 µµfd
C8 .01 µfd
C9 7-45 µµfd
C10 7-45 µµfd
C11 50 µµfd
C12 7-45 µµfd
C13 7-45 µµfd
C14 5 µµfd
C15 .01 µfd
C16 7-45 µµfd
C17 7-45 µµfd
C18 50 µµfd
C19 7-45 µµfd
C20 7-45 µµfd
C21 3-30 µµfd
C22
C23 50 µµfd
C24 50 µµfd
C25 100 µµfd
C26 .01 µfd
C27 50 µµfd
C28 50 µµfd
C29 50 µµfd
C30 .01 µfd
C31 .002 µfd
C32 250 µµfd
C33 100 µµfd
C34 .01 µfd
C35 .01 µfd
C36 .01 µfd
C37 .01 µfd
C38 .01 µfd
C39 .01 µfd
C40 .01µfd
C41 .01 µfd
C42 .01µfd
C43 .01 µfd
C44 100µµfd
C45 100 µµfd
C46 .01µfd 400V
C47 .01µfd
C48 .002µfd 400V
C49 .001 µfd 400V
C50 .01 µfd
C51 10µfd 25V
C52 24 µµfd
C53 35 µµfd
C54 35 µµfd
C55 24 µµfd
R1 270Ω .5W
R2 27K .5W
R3 15K .5W
R4 2K .5W
R5 10K .5W
R6 27K .5W
R7 27K .5W
R8 22K .5W
R9 27K .5W
R10 2K .5W
R11 100K .5W
R12 270Ω .5W
R13 47K .5W
R14 2K .5W
R15 2K
R16 100K .5W
R17 2.2 Meg .5W
R18 270Ω .5W
R19 47K .5W
R20 2K .5W
R21 47K .5W
R22 1 Meg .5W
R23 820K .5W
R24 270K .5W
R25 270K .5W
R26 500K
R27 10 Meg .5W
R28 270K .5W
R29 470K .5W
R30 560Ω 1W
R31 2K .5W
R32 6K 5W

Coil Data For The Modified W2AEF Mobile Receiver

75 Meters

L1—same as original receiver.
L2—same as original receiver.
L11—58 turns, #34, enam. of LS-3 form.
L16—same as original receiver.

40 Meters

L3—4 turns #20 enam. around bottom turns of L4. First wrap Scotch tape around L4 and then wind on L3.
L4—30 turns #28 enam. on LS-3 or LS-5 form.
L12—25 turns #32 enam. on LSM or LS-6 form.
L17—19 turns #32 enam. on LS-6 form.

20 Meters

L5—3 turns #20 plastic covered wire wound over bottom turns of L6.
L6—18 turns #20 enam. on LS-5 form.
L13—15 turns #26 enam. on LSM or LS-6 form.
L18—9 turns #26 enam. on LS-6 form.

15 Meters

L7—2 turns #20 plastic covered wire wound over bottom turns of L8.
L8—14 turns #22 enam. on LSM or LS-6 form.
L14—12 turns #20 enam. on LSM or LS-6 form.
L19—6 turns #24 enam. space wound on LS-6 form.

10 Meters

L9—2 turns #20 plastic covered wire over bottom turns of L10.
L10—14 turns #28 enam. on LSM or LS-6 form.
L15—10 turns #18 enam. on LSM or LS-6 form.
L20—6 turns #24 enam. space wound on LS-6 form.

Notes: Except where indicated the coils are close wound. The coil forms are made by Cambridge Thermionic Corp. The LS-3 is 3/8" in diameter (paper phenolic), LS-5 is 3/8" in diameter (ceramic), LS-6 is 1/4" in diameter (ceramic) and the LSM form is 1/4" in diameter (paper Pheolic).

original oscillator circuit is retained, with the screen grid of the 6AU6 acting as the oscillator plate. Well-isolated electron coupling from the 6AU6 plate is used for oscillator voltage mixer injection, and oscillator pulling is thereby greatly reduced. Over-all stability is also improved.

Only three sets of trimmer capacitors are used for bandspread and tracking over all the bands in the mixer and oscillator stages. One set is used in each tunable stage for the 10-meter band, another set is used for the 75-meter band, while the third set serves for the three remaining bands, 15, 20 and 40. The latter trimmer sets are switched into the circuit, as required, either by switch *C* or switch *E*. When the bandspread on 40 is set for 7 to 7.3 Mc., the spread on 20 will be approximately 14 to 14.45 Mc., and that on 15 will be approximately 21 to 21.6 Mc. The range on the other bands is 3.7 to 4 Mc., and 28 to 29.8 Mc.

Only the r-f front end of the receiver need be modified; no other changes are required.

Tuning is conducted in the same manner as with the original receiver, except that the h-f oscillator is tuned to the fundamental frequencies for all ranges, i.e. the range of the desired band plus the second mixer frequency (approx. 1500 kc.). For the 10-meter band it will now be 29.5-31.3 Mc., the 15-meter band 22.5-23.1 Mc., the 20-meter band 15.5-15.95 Mc., the 40-meter band 8.5-8.8 Mc., and the 75-meter band 5.2-5.5 Mc.

The 10 and 75-meter bands should be first aligned and set for tracking. The 40-meter band should be done next by setting the h-f range with the oscillator trimmer *C14* and the oscillator slug *L17*. The oscillator range for 15 and 20 meters should then be set by the slugs in *L19* and *L18* only, *without* any readjustment of *C14*. Peaking and tracking of the mixer stage should

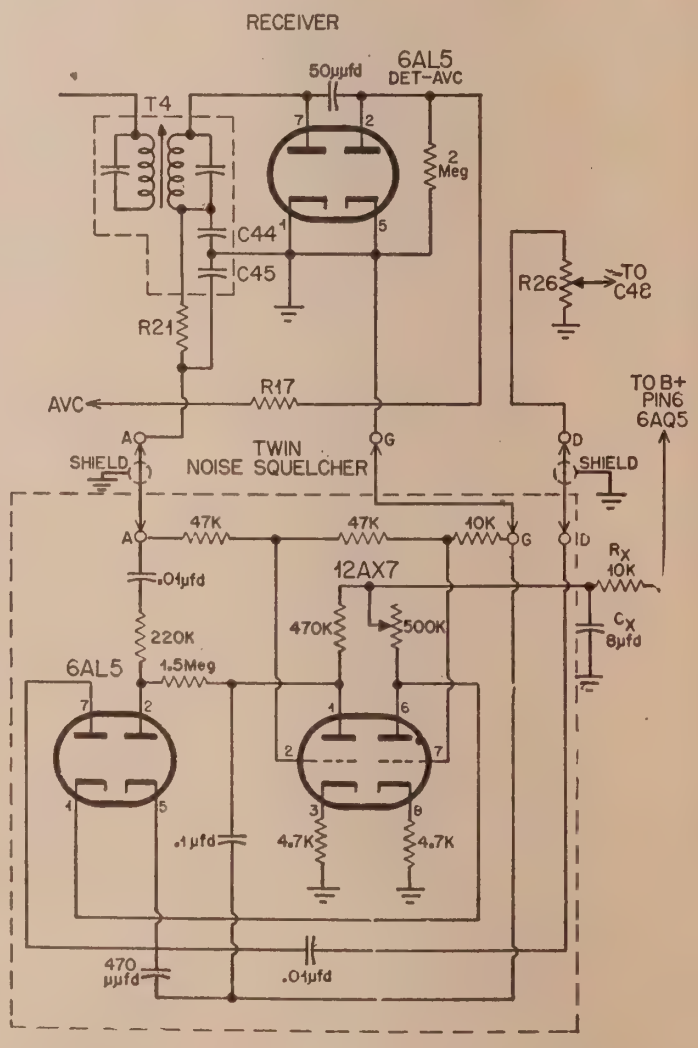


Fig. 3-8-C. Circuit modification to add the TNS unit. Details on operation of this noise silencing device appears in Chapter 4.

now be adjusted on the 20-meter band with *C6* and *L13*. Mixer adjustment for 15 and 40 is now made with *L14* and *L12* only, *without* any readjustment of *C6*. Tracking in the r-f stage will be obtained when the slugs in this stage are adjusted in conjunction with the antenna trimmer capacitor *C2*. For 10 meters the setting of this capacitor will be about 1/3 the value from minimum, for 15, 20 and 40 it will be near maximum, and for 75 it will be near minimum.

Adding the Twin Noise Squelcher to The Standard of Comparison Receiver

The *Twin Noise Squelcher* may be added to the receiver, either as an outboard unit or as an integral part of the set.

Rewiring of the detector and a-v-c circuits should be made according to *Fig. 3-8-C*. *R17, R21, C44, C45* and *R26* are original components. *T4* is the original last i-f transformer. Connections between receiver and *TNS* at points *A* and *D* should be individually shielded leads. The connection at *G* need not be shielded.

Rx and *Cx* usually are not required; however, if feedback or motorboating is experienced when the volume control is advanced, the filter composed of *Rx* and *Cx* will be required.

Chapter Four

Noise Suppression

4.1—Ignition Noise Problems

The automobile, in addition to being a means of transportation, and a container for mobile equipment, is also a prolific source of noise generation. The noise may be generated by the primary and secondary electrical circuits of the car, or it may be generated by static electricity caused by the movement of the car through the atmosphere.

Complete elimination of radio noise cannot be expected as the very nature of the ignition system is such that radio frequencies must be produced or else no ignition will result. The high frequency components cannot be eliminated without eliminating or deteriorating the ignition spark itself. Noise reduction, therefore, is noise suppression, rather than noise elimination. It is usually simple enough to suppress noise to a tolerable level, without the rigors of complete electrical shielding, such as used in certain military installations.

The problem of noise can be attacked two ways: The discovery and suppression of the noise at the source, or the addition of a noise limiter to the receiver in the car. The noise limiter is especially valuable in eliminating noise generated by other cars in the immediate vicinity, as well as reducing noise generated by your own car. Both methods of attack must be used for a successful mobile installation.

Noise Reduction

From the noise generating point of view the automotive electrical system may be divided into two parts. First, the generator/regulator system (primary) and second, the ignition (secondary) system. Radio noise may eminate from either or both of these systems. A quick test will indicate the guilty system. Run the car at a medium speed with your receiver tuned to the frequency most affected by noise. Close the throttle and turn off the ignition key allowing the car to coast in gear with the clutch engaged. If the noise stops the trouble is in the generator/regulator system. If the noise continues but with diminished volume, both the ignition and generator/regulator systems are creating noise.

Generator/Regulator System Noise

Generator hash is heard in the form of a low or high pitched whine that varies in pitch with the speed of the motor. In order to prevent the power leads from the generator from radiating this hash a 0.1 μfd. coaxial type condenser (*Sprague 48P9*) may be mounted on the dynamotor frame and connected directly in series with the armature lead (*A lead*). Most cars equipped with broadcast receivers have a large paper condenser bypassing the *A* lead. This condenser has too much internal inductance to be effective as a r-f filter above 2 Mc., so it should be removed and the coaxial condenser substituted for it. In addition, residual noise may be caused by dirty or rough commutator segments or poor fitting brushes. These should be checked and serviced by a competent generator mechanic.

In certain systems where it is impossible to eliminate the noise with these precautions a trap consisting of a 50 $\mu\mu$fd. condenser in parallel with a coil wound on No. 10 wire and tuned to the operating frequency may be placed in series with the *A* lead at the generator. The trap should be tuned for maximum reduction of noise in the receiver.

A smooth sounding noise from the generator is caused by *shaft hash*. This noise is caused by static electricity building up on the rotating shaft of the generator. The shaft is partially insulated to ground by a thin oil film. When the static electricity builds up to a sufficiently high potential to flash through the oil film, it creates radio noise. The shaft may be grounded by mounting a grounding brush to ride on the pulley of the generator. This brush will drain off the accumulating charge on the shaft.

Regulator hash can be identified as a regular crackling noise of even loudness. This type of radio noise shows up generally in the 10, 11 and

15-meter bands. It is caused by sparking at the points of the regulator contacts. It is an intermittent noise as it appears only when the regulator is working. To eliminate this noise, a 0.1 μfd. coaxial condenser should be placed in the battery lead (*B* lead) directly at the regulator, with the case of the condenser grounded to the frame of the regulator. A second 0.1 μfd. coaxial condenser should be put in the armature lead (*A* lead) directly at the regulator. Its case, also, should be well grounded. The remaining lead is the field lead (*F*). This cannot be bypassed as the other leads without damage to the regulator. However, a 0.002 μfd. mica condenser in series with a 4-ohm 1-watt carbon resistor from *F* lead to ground will suppress the noise in this lead. *Figure 4-1-A* shows a complete regulator installation. The various filters are mounted to an "L" shaped metal plate bolted to the base of the regulator.

For stubborn cases, the regulator may be disconnected from the circuits by a switch in the *F* lead, and a 30-ohm 25-watt potentiometer connected from the generator field to ground to manually control the charging rate of the battery. However, such a drastic step as this is seldom required.

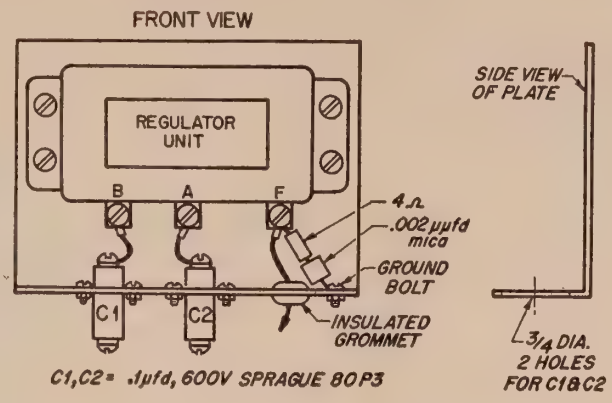


Fig. 4-1-A. A decided improvement in mobile noise reduction will result from the use of coaxial capacitors in the leads to the voltage regulator.

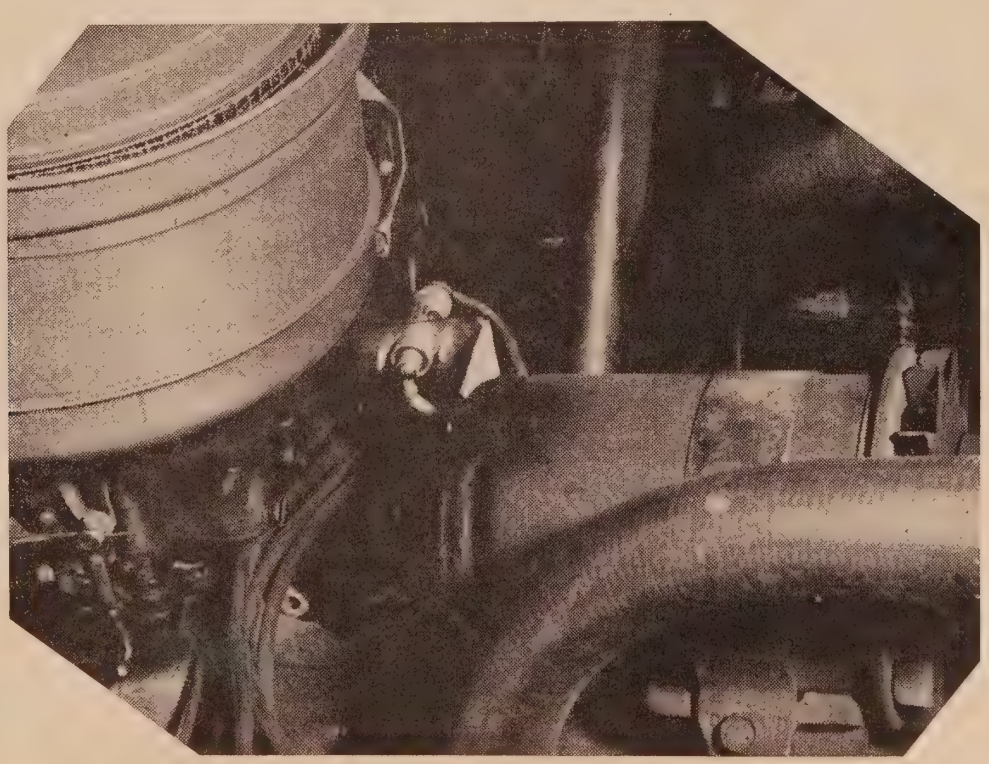
Ignition Noise

Having disposed of the noise from the generator/regulator system, we will now examine the secondary electrical system of the car: the ignition system. *Figure 4-1-B* shows a typical ignition system complete with supression devices.

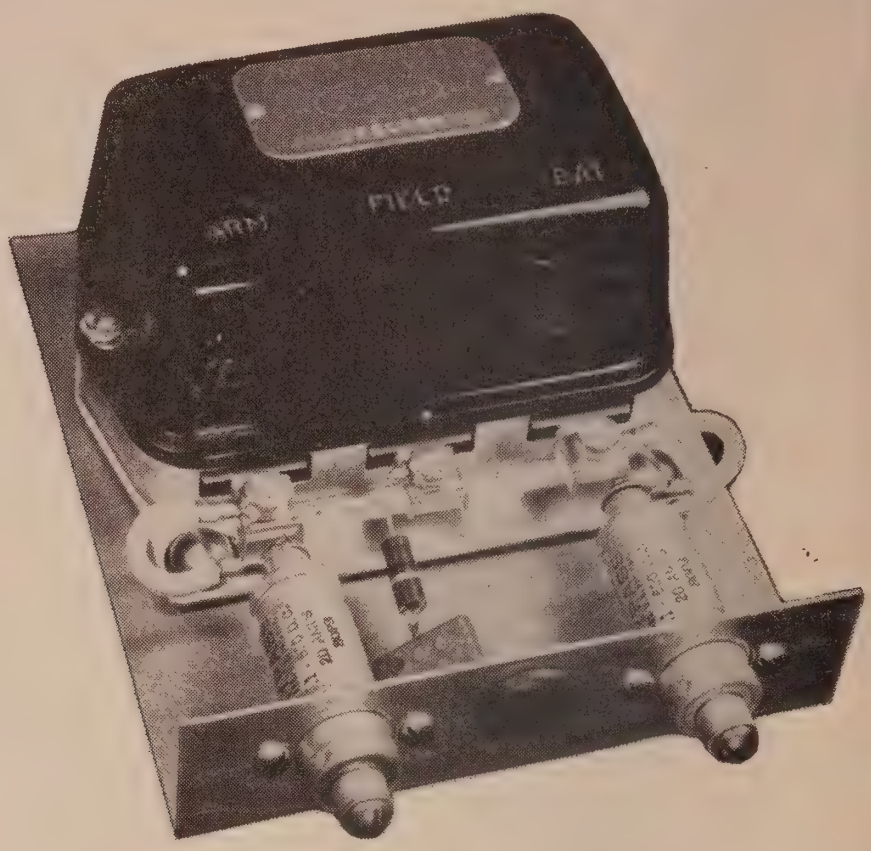
Wiring: The high-voltage ignition wiring is often a source of noise radiation in itself. The metal connecting caps on the ends of the ignition leads are usually crimped on to the wire ends. This results in a poor electrical connection at these points with the possibility of noise generation. These caps should be removed, cleaned and soldered to the wire conductor. The cables should be wiped clean of grease and dust and inspected for breaks or cracks in the insulating material. Fibre spacers may be made to hold the cables away from each other and from the motor itself.

Ignition Coil: The coil, even though in a metal can, frequently radiates considerable noise. A piece of strip brass soldered to the can and securely grounded to the car frame at the opposite end will help. A 0.1 μfd. coaxial condenser should be mounted on the car frame and the primary lead from the coil run through this condenser to the primary ignition circuit.

Distributor: The distributor, as the name implies, correctly distributes the firing spark to the proper plug at the proper time. It is a high-voltage rotary switch, cam driven by the automobile engine. When the rotor electrode is positioned near a stator terminal in the distributor, the air gap breaks down and a conducting arc is established. The establishment of this arc, combined with the abrupt drop in secondary voltage, generates considerable radio noise.



Generator hash in the Ham bands may be reduced by replacing the paper capacitor across the generator with a coaxial type. This mounting shows a Sprague 48P9.



Actual mounting of the regulator hash suppression condensers used in conjunction with a Ford regulator —note the change in the positions of the terminals.

A 10,000-ohm suppressor *(Erie L7VR-10ME)* in the center distributor arm lead and 5000-ohm suppressors *(Erie L7VR-5ME)* in each spark plug lead at the distributor will effectively suppress the noise from this source. Be sure these suppressors make good electrical connections to the lead wires.

Spark Plugs: The spark plug potential varies rapidly between some 8000 volts unfired and 1500 volts when fired. These rapid changes generate a tremendous amount of radio noise, heard as a popping sound running in step with the speed of the car motor. A 10,000-ohm suppressor located at each plug is necessary to reduce this source of noise. In general, three methods may be used to introduce this suppression into the circuit: 1) The use of suppressors, as mentioned above. 2) The use of suppressor or resistor-type spark plugs. 3) The use of resistive ignition cables. Satisfactory results may be obtained by using one or more of these methods. The motor timing should be readjusted after the insertion of the suppressors.

Other Noise Sources

Instruments: The gas gauge, heat gauge, oil gauge and certain other instruments can produce considerable radio noise in the car. The most practical way to determine this after the primary and secondary electrical circuit noise has been reduced is to disconnect all the "hot" leads to the gauges. With the receiver gain turned up, the leads are replaced one by one while listening for a change in the noise level. The gauge noise usually takes the form of a periodic, rasping sound. Most of this can be eliminated by installing a coaxial 0.1 μfd. condenser at the position where the gauge is mounted, and grounding the condenser case to the frame of the car. It may also be necessary to provide another condenser at the proper instrument terminals on the dashboard of the car.

Wheel Static: Shows up as a steady popping sound at medium or high speeds on dry roads. It is more noticeable on some surfaces than on others. As in the case of the generator, it is caused by static electricity building up on the wheels, which are insulated from the car by a thin film of grease in the axles. When this film of grease breaks down and allows the electrical charge to flow to ground, the popping noise is produced. Static collectors may be bought from a car dealer and placed inside the front wheel hub caps. These effectively ground the wheel to the axle and prevent the accumulation of wheel static. Rear wheel static collectors may also be purchased on special order through your local automobile dealer.

Tire Static: Some tires create a radio noise that is generated between the inner tube and the inside casing of the tire. This may be eliminated by injecting a special anti-static powder into the tire through the air valve. The

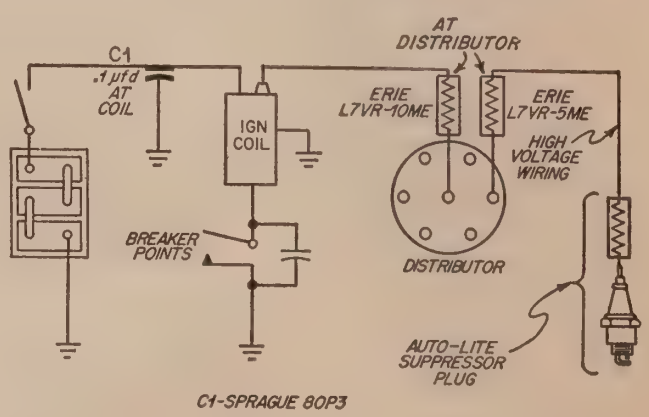


Fig. 4-1-B. This is a typical ignition system with suppression devices at every trouble spot.

powder and injector may be obtained through some dealers, although it does not seem to be a universally stocked item.

Imperfect Bonding: Certain parts of the automobile are either ungrounded, or have an imperfect ground path to the chassis of the car. The exhaust pipe and muffler should be bonded to the frame of the car at several points by a short, flexible braid. The engine block and firewall should both be bonded to the car frame. The steering column, control leads, choke, and temperature control leads should be bonded (or bypassed with coaxial condensers) where they pass through the firewall. This will prevent these leads from conducting radio noise into the interior of the car. Attention should be given to any lead that passes through an insulated opening in the firewall into the interior of the car.

Antenna Installation Precautions: The transmission line from the receiver to the antenna must be bonded to the frame of the car at the antenna end, and bonded to the receiver chassis at the receiver end. The receiver chassis should be grounded to the car frame with as low resistance a ground connection as can be made. This should, if possible, be a separate ground from the one that supplies power to the receiver. If the antenna is of the usual whip design, it may be noticed that at high speeds on dry pavements a high pitched whine may be heard in the receiver. This is known as *velocity static* created by the metal area of the car picking up static charges. Since the antenna is the highest point on the car, it will discharge this static and create the high pitched noise. Some antennas have a plastic ball on the tip to stop this effect. If this is missing, a short length of cambric tubing slipped over the tip of the antenna will do the job. Seal the top end of the tubing with Duco cement or nail polish and wrap it with friction tape to hold it in place. The cambric tubing will slowly discharge the velocity static at a rate that cannot be heard in the receiver.

4.2—Noise Limiters

The job of noise suppression described in *Chap. 4.1* can be completed through the addition of a noise limiter or silences to the automobile receiver. This is the only way to suppress noise generated by cars other than your own!

Noise reduction circuits have been developed for application at any one of several places in a receiver. Of all these circuits the most simple is the type employing one or two diodes (in either a half-wave or full-wave configuration) connected in series or shunt with the audio connection between the second detector and the first audio stage of the receiver.

The Nature of Noise Interference

The most common types of noise plaguing the mobile operator are the pulse noises such as car ignition, atmospheric noises and spark discharges. Compared to the length of a cycle at usual speech frequencies the noise pulses are usually of short duration and spaced widely apart *(Fig. 4-2-A)*. The reason that these pulses blank out so much of the wanted signal, in spite of the fact that sometimes several cycles of the wanted signal may appear between noise pulses, is that the pulse amplitude of the noise is usually so much greater than the desired signal level that when the pulse hits the receiver the speaker vibrates much longer than the duration of the noise pulse. While the human ear can easily separate a coherent signal from noise, it seems to have a built-in a-v-c system which automatically desensitizes itself from the noise. This action of the ear, combined with the acoustical characteristics of present day reproducers tends to fill in the gaps between noise pulses to such a degree that most, if not all, of the desired intelligence may be lost.

The receiver i-f amplifier will also lengthen the duration of the noise pulse; the exact amount of lengthening depending upon the i-f bandwidth. High *Q* circuits will "ring" or continue to oscillate beyond the actual duration of the pulse, a narrow bandwidth causing greater ringing action than a broad bandwidth. This action of the i-f amplifier would indicate the desirability of applying noise limiting principles to the i-f section of the receiver before the pulses can be lengthened. Some circuits have been devised for this purpose. Fortunately most noise trains have sufficient space between individual pulses that by the time they reach the second detector the simple limiter circuits can do a good job. All that needs to be done is to limit the noise pulses in amplitude to a level near that of the desired signal so that most of the intelligence between the noise pulses can be recovered *(Fig. 4-2-B)*. The three types of limiter circuits illustrated herein offer the most effective action for the least complicated circuitry.

Simple Shunt Limiter

The short circuit type of noise limiter, known as a *Shunt* limiter is a diode in series with d-c bias connected in shunt across the audio output of the second detector of the receiver *(Fig. 4-2-C)*.

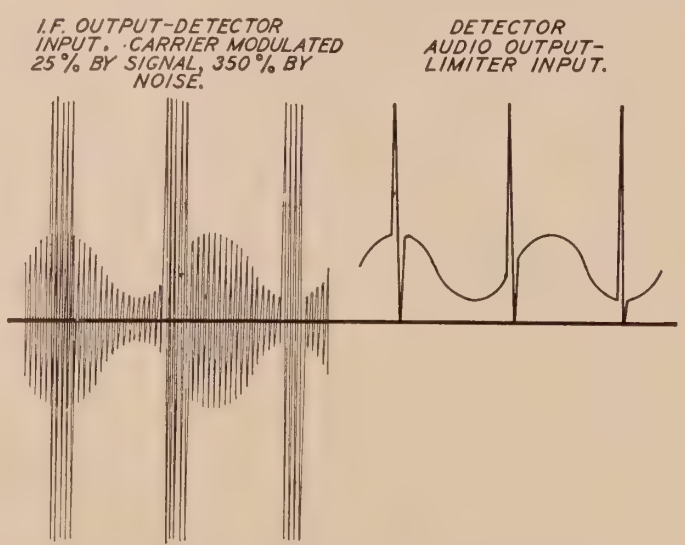


Fig. 4-2-A. A duration/amplitude comparison of noise pulses vs. desired signal modulation.

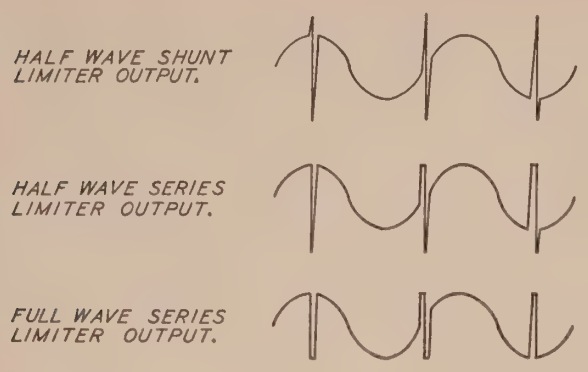


Fig. 4-2-B. To recover the intelligence in the signal the most common types of noise limiters restrict the pulse amplitude. The relative efficiency of the three basic types is shown above.

The polarity of the diode and bias is so arranged that the diode will not conduct until the signal or noise voltages exceed the bias level. When the bias level is exceeded, the diode conducts and acts as a low resistance path to ground for the excessive voltage. Since the usual vacuum tube diode is not a "perfect" diode but contains an internal resistance, a resistor is connected in series between the detector output and the limiter so that the combination of the two resistances will act as a voltage divider. This is necessary to step down the amount of noise voltage passed on to the audio circuit when the imperfect diode conducts. While it reduces the audio voltage, its effect on reducing the noise pulses exceeding the bias level is proportionately much greater *(Fig. 4-2-D)*.

This circuit is capable of doing a good job on a steady signal where the bias can be set to barely let the audio peaks go by untouched but clip all the noise pulses down to about the same value. However, most signals fade up and down so rapidly that it would be impossible to follow the signal level with a manual bias control. Thus a bias setting for a weak signal would severely clip the audio of a strong signal; however, the bias setting could be taken care of automatically by the same source from which the receiver a-v-c bias is obtained. This provides a d-c bias which is determined by the carrier level, and by adjusting the proportion of audio voltage and automatic bias applied to the limiter from the second detector, the limiter can be designed to clip all voltages above a predetermined percentage of modulation. By making one of the resistors of the circuit a potentiometer instead of a fixed resistor a certain percentage of modulation may be chosen at which limiting will begin, and the limiter will then automatically clip at this level no matter how much the signal is fading.

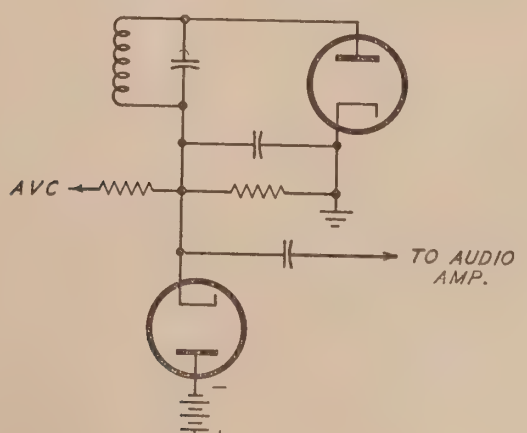


Fig. 4-2-C. The simplest type of noise limiter places a diode in shunt across the audio output of the second detector.

Clipping Percentage

For those who prefer extreme simplicity, a fixed percentage of clipping can be quite satisfactory. The clipping level may be set as low as 30%-40% modulation before audio distortion becomes objectionable. If the *average* modulation level is much higher than this, such as in equipment using speech clipping or compression, the noise limiter must be set at a correspondingly higher clipping level to prevent

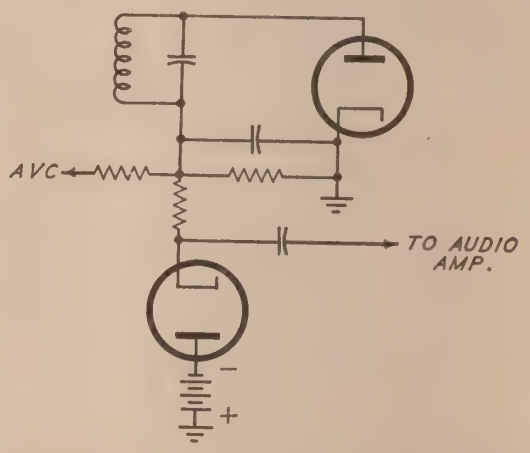
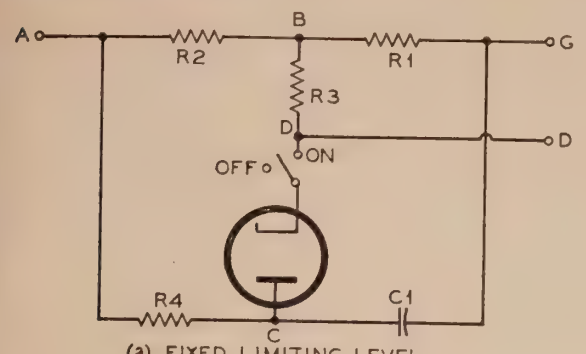


Fig. 4-2-D. A common practice when using diodes in the shunt limiter is to insert a resistance between the detector and the limiter. This reduces the effect of the internal resistance of the diode upon the limiting action.

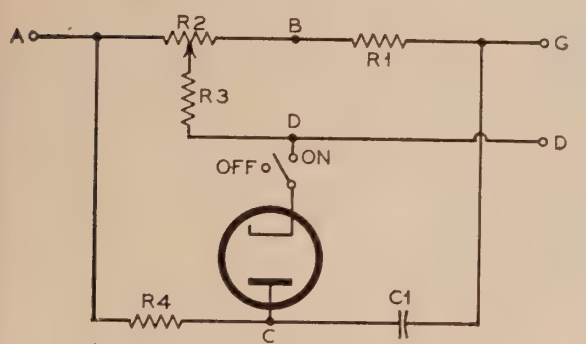
severe audio distortion. The reason for setting the limiter to the lower average percentage of modulation rather than at the 100% value is so that it can bring all the noise peaks down close to the average audio signal level.

Figure 4-2-E shows a shunt limiter suitable for connection between a diode second detector and the first audio amplifier grid. *R1* and *R2* make up the detector load resistor and should total about the same as the value presently in the receiver to be modified. The usual value is about 500,000 ohms. *R4* and *C1* provide the automatic bias for the diode. *R3* is the series dropping resistor which provides the voltage divider action previously mentioned. The value of *R3* should be about equal to the value of the grid resistor of the audio amplifier to which the noise limiter output is connected. This is usually 500,000 ohms. An audio coupling condenser should be used between the limiter and the volume control or audio grid lead to prevent d-c voltage from reaching the audio grid.

The ratio of *R2*/*R1* will determine the percentage of modulation at which the clipping action takes place. A ratio of 1:1 will cause the



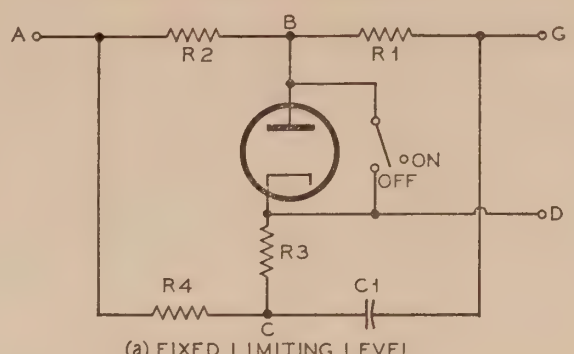
(a) FIXED LIMITING LEVEL



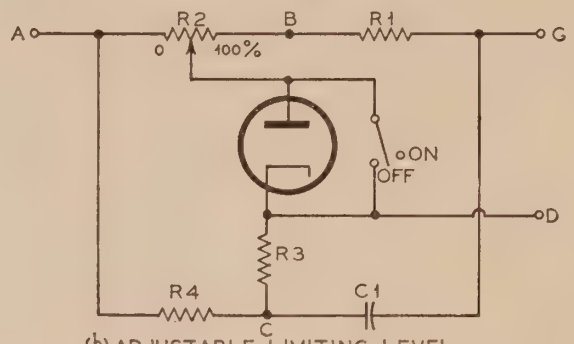
(b) ADJUSTABLE LIMITING LEVEL

POINT "A" IS OUTPUT TERMINAL OF RCVR. 2ND DETECTOR.
POINT "D" IS NOISE-LIMITED AUDIO OUTPUT TERMINAL.
POINT "G" IS GROUND.

Fig. 4-2-E. These are two of the most commonly employed shunt type noise limiters.



(a) FIXED LIMITING LEVEL



(b) ADJUSTABLE LIMITING LEVEL

Fig. 4-2-F. These are representative half-wave series type noise limiters. The interpretation of connection points, "A", "D" and "G" is given in Fig. 4-2-H.

iode to clip at approximately 100% modulation. Where a variable modulation clipping ontrol is not used, a clipping level of 40% is ecommended. *Table 4-2-A* shows typical values or *R1* and *R2* for various levels of clipping.

Simple Series Limiter

The series or open circuit limiter depends n the limiter diode conducting at normal sig- al levels and opening on high modulation mplitudes or noise peaks. Since the diode is n series with the audio path, this action will ffectively clip the noise peaks. *Figure 4-2-F* is representative half-wave series limiter circuit. germanium crystal diode is not suited as a eries limiter since the back resistance is too ow, whereas the vacuum tube diode will cut off or all voltages above the clipping level. *Table -2-B* contains typical circuit values. In the eries limiter the values of all resistors *R1, R2, 3* and *R4* have an effect on the threshold level. Where *R3* equals *R4, R3* plus *R4* in parallel ith *R2* should equal *R1* for 50% limiting, and hould equal twice *R1* for a limiting level of 00%. If a limiter is to be connected to a de- ector having a 500,000-ohm load, the sum of all the conducting branches of the limiter and the new load resistor should equal 500,000 ohms. If it is desired to make the clipping level adjustable, *R2* can be made a potentiometer. Zero to 100% modulation level of positive peak clipping can be selected as the arm of *R2* is moved from *point A* to *point B*. As in the shunt limiter, if two diodes are available for use in the half-wave series limiter they should be connected in parallel. This will lower the effective internal resistance and permit higher audio output as well as a more nearly constant clipping level.

The half-wave circuit clips at not less than 100% on negative peaks, regardless of the clipping level on positive peaks. A full-wave clipper will provide equal clipping of both positive and negative peaks.

Full Wave Noise Limiter

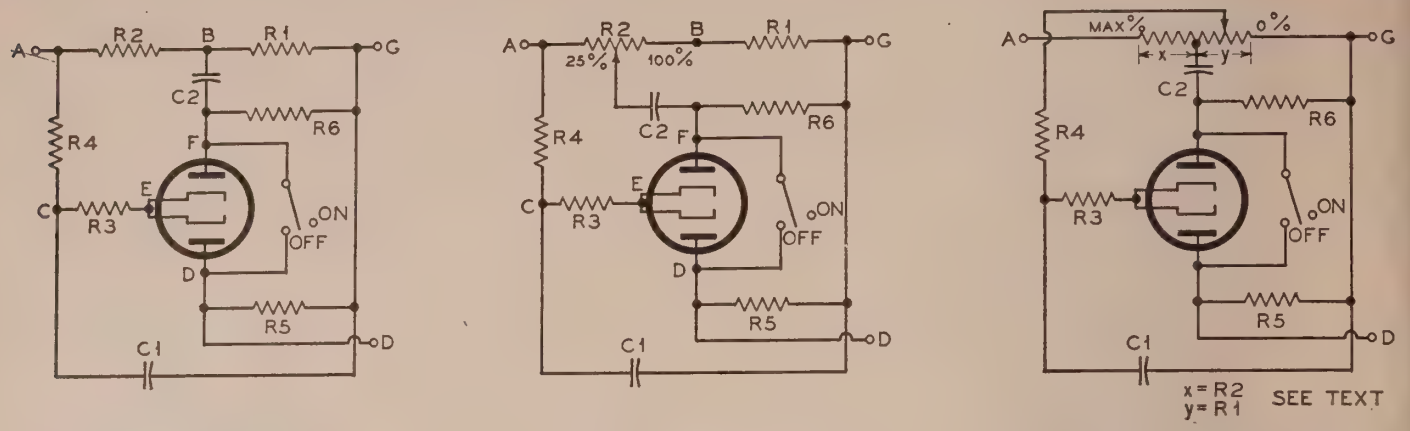
The full-wave noise limiter circuits that afford

R_3 = 500k	C_1 = 0.05 uf	R_4 = 1.0 Meg	
% limiting	R_2/R_1	R_2	R_1
100%	1/1	250k	250k
50%	1/2	166k	333k
40%	2/5	140k	360k
30%	1/3	125k	375k
0-100%	1/1	250k pot.	250k

Table 4-2-A. Typical component values that may be substituted in Fig. 4-2-E to provide indicated clipping levels.

C_1 = 0.05 uf	R_3 = 500k	R_4 = 1.0 Meg	
% limiting	$(R_3+R_4 \parallel R_2)/R_1$	R_2	R_1
100%	3/1	500k	125k
50%	3/2	475k	200k
40%	6/5	375k	225k
30%	1/1	300k	250k
0-100%	3/1	500k pot.	125k
C_1 = 0.05 uf	R_3, R_4 = 1.0 Meg		
% limiting	$(R_3+R_4 \parallel R_2)/R_1$	R_2	R_1
100%	2/1	400k	166k
50%	1/1	285k	250k
40%	4/5	250k	275k
30%	3/5	220k	310k
0-100%	2/1	400k pot.	166k

Table 4-2-B. Circuit component values for substitution in Fig. 4-2-F to obtain indicated clipping levels.



(a) FIXED LIMITING LEVEL

(b) ADJUSTABLE LIMITING LEVEL LIMITED MINIMUM RANGE

(c) ADJUSTABLE LIMITING LEVEL RANGE 0 TO SELECTED MAXIMUM

Fig. 4-2-G. These circuits are variations of the full-wave series type noise limiter.

the best limiting action with the fewest parts are the series diodes *(Fig. 4-2-G)*. The diodes are arranged so that with any d-c output voltage from the detector both sections will be conducting. The audio voltage will then be coupled to the audio amplifier through *C2* and the two diodes. On peaks causing large negative voltages at *point B*, diode *E-F* will cut off, and on peaks tending to reduce the carrier to zero, diode *D-E* will cut off. To obtain symmetrical clipping *R5* and *R6* should be twice the value of *R3*. See *Table 4-2-C* for full-wave series circuit values. If *R2* is a potentiometer with *C2* connected to the arm, a clipping level between 100% and 30% can be selected, maximum audio output being secured at the most useful clipping levels in the region 30-50%.

Connecting the Noise Limiter in the Receiver

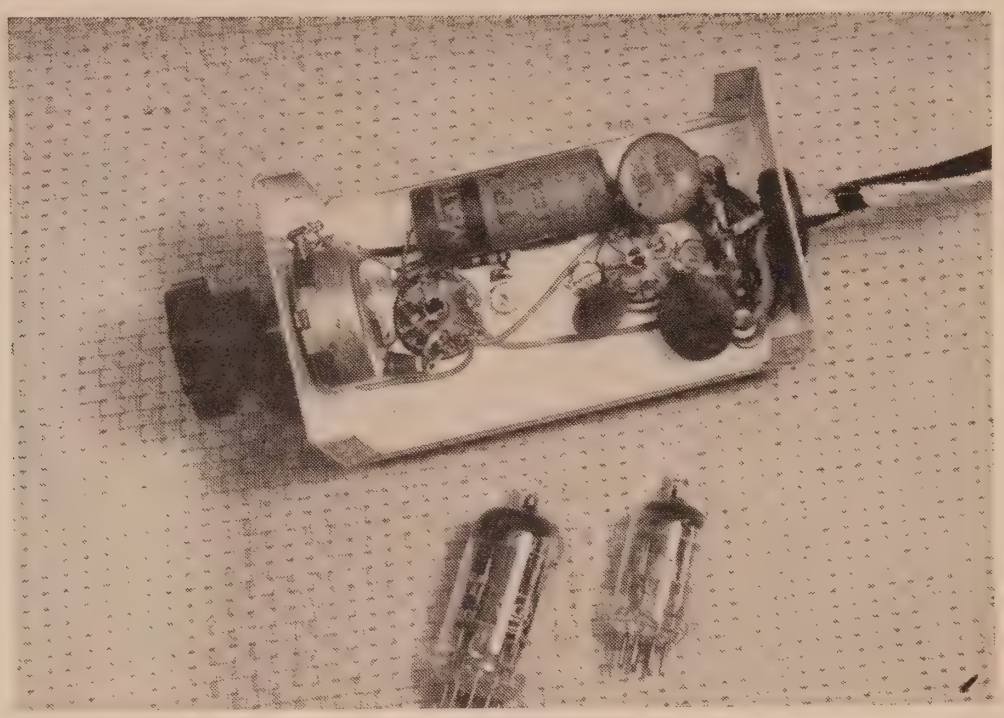
Incorporating any of the limiter circuits described into a conventional automobile receiver is relatively easy. The circuits of *Fig. 4-2-H* are representative of the more common second detector circuits. Dotted lines are shown for the connections to be removed before insertion of the limiter. The existing detector load resistor should be removed. Insert the limiter circuit chosen with *points A, G* and *D* of the limiter circuit connected to the corresponding lettered points. Long leads in the audio path should be avoided if possible, otherwise shielded wire should be used. For the series limiter circuits care should be taken to keep down any possible capacity coupling between the input and output circuits of the limiter. The leads to the *on-off* switch should be as short as possible and should be kept apart. The a.v.c. circuit for the receiver should be left undisturbed if at all possible. The connection of the limiter at *point G* into the detector circuit should be to the same point as that of the detector load resistance before modification, even though it may not be at ground potential. (For example, certain delayed a.v.c. circuits.)

Additional Notes

1. The values of the resistors and condensers in *Tables 4-2-A, 4-2-B* and *4-2-C* are for second detectors having a 500,000 ohm load resistor before modification. For detector circuits having a substantially different load resistance, the resistor values must be changed by the ratio of the load resistance to 500,000 ohms. Thus, if the detector has a load resistance of 200,000 ohms, each resistance value in the above figures should be multiplied by 2/5. *C1* should be then increased by a ratio of 5/2. *C2* may remain the value given in the table as it is not critical as to capacity.
2. For proper operation of a limiter of any type, the i-f signal level should be high enough to overcome the emission potential of the diode tube. Frequently better limiting action can be obtained by reducing the filament voltage of the diode tube.
3. It has been the experience of most Hams that a 6H6 makes a better noise limiting diode than a 6AL5 and that either one of them is better than a crystal.

C_1 = 0.1 uf	C_2 = 0.02 uf	R_3, R_4 = 500k	
R_5, R_6 = 1.0 Meg			
% limiting	R_2/R_1	R_2	R_1
100%	2/1	500k	250k
50%	1/2	250k	500k
40%	1/5	125k	625k
33%	---	0	750k
33-100%	2/1	500k pot.	250k
C_1 = 0.05 uf	C_2 = 0.02 uf	R_3 = 500k	
R_4, R_5, R_6 = 1.0 Meg			
% limiting	R_2/R_1	R_2	R_1
100%	3/1	5ook	166k
50%	1/1	333k	333k
40%	3/5	250k	415k
25%	---	0	660k
25-100%	3/1	500k pot.	166k

Table 4-2-C. Suggested component values for insertion in Fig. 4-2-G to obtain optimum or desired clipping levels.



Construction of the TNS is simplicity in itself. This unit provides squelch action as well as noising silencing properities to improve mobile reception.

4.3—The TNS

Until the development of the *TNS* (Twin Noise Squelcher) the full-wave series limiter was found to be superior to all other types of limiters. Results in limiting noise pulses when receiving a signal were quite satisfactory, but during standby receiving periods, or while tuning around the band for signals, the residual background noise produced by the clipped noise pulses of the series limiter is very high. It is especially annoying when driving on concrete highways where the reinforcing steel grids of the concrete carry ignition pulses for many miles.

The *TNS* is a very effective noise silencer. Under severe highway noise conditions, the *TNS* performs better than the full-wave series limiter in regards to audio-to-background noise ratio, and intelligibility. Under bad noise conditions the squelching action of the *TNS* not only eliminates the tiring background grind, but it also enables the operator to easily find a weak signal. With the usual type of noise limiter even a moderately strong carrier is sometimes hard to find in the background noise, unless the carrier has modulation on it. With proper setting of the *TNS* extremely high level ignition pulses from busses and trucks are eliminated, something that is almost impossible to do with the usual noise limiter.

Of particular import for the mobile operator using the broadcast receiver, the *TNS* does not distort audio peaks and may be left permanently in the circuit.

Operation of the TNS

In operation, (see *Fig. 4-3-A),* both grids of the dual triode tube *(V1)* receive bias variations at the rate of the audio frequency. The plate current of *section B* of *V1* varies at the audio rate and is coupled to the cathode of *section B* of the limiter tube *V2*. The plate current of *section A* of *V1* varies at an *average* rate due to filter components *C1, C2* and *R3*. The plate loading resistors *R6* and *R7* are chosen so that with no audio excitation from the detector, the positive voltage on the plate of *section A* of *V2* is slightly higher than the positive voltage on the cathode of *section B* of *V2* resulting in a current flow through the limiter tube. Since the plate of *section B* of *V1* is coupled to the cathode *section B* of *V2* an audio signal is obtained from the output of the limiter tube, *V2*. If a

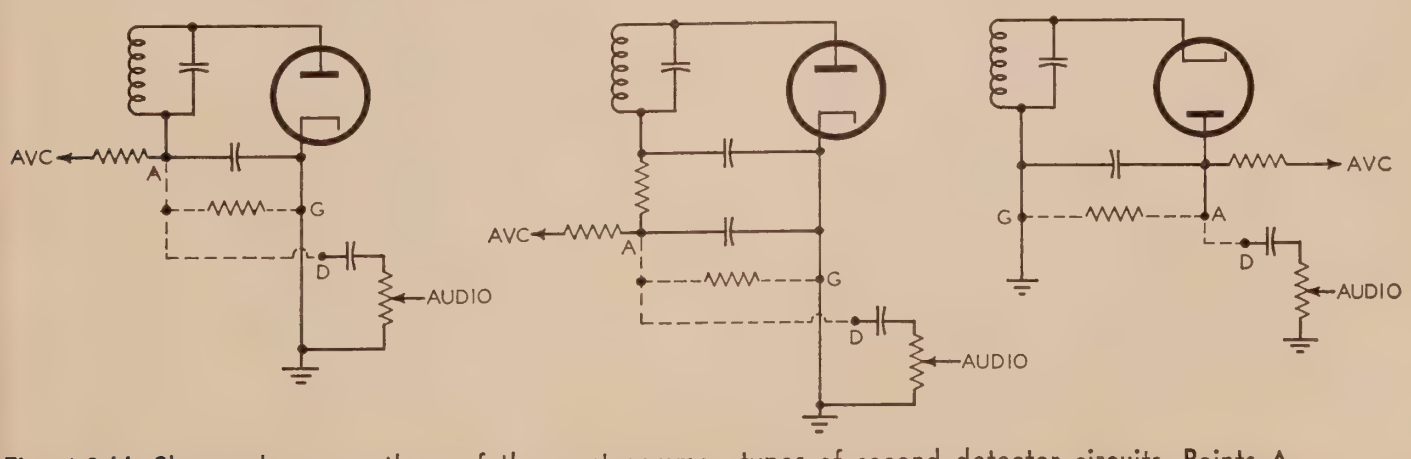


Fig. 4-2-H. Shown above are three of the most common types of second detector circuits. Points A, D and G correspond to similar junctions in Figs. 4-2-D, 4-2-E, 4-2-F, and 4-2-G. Any one of those circuits may be inserted in the second detector by removing the load resistor shown in the dashed lines.

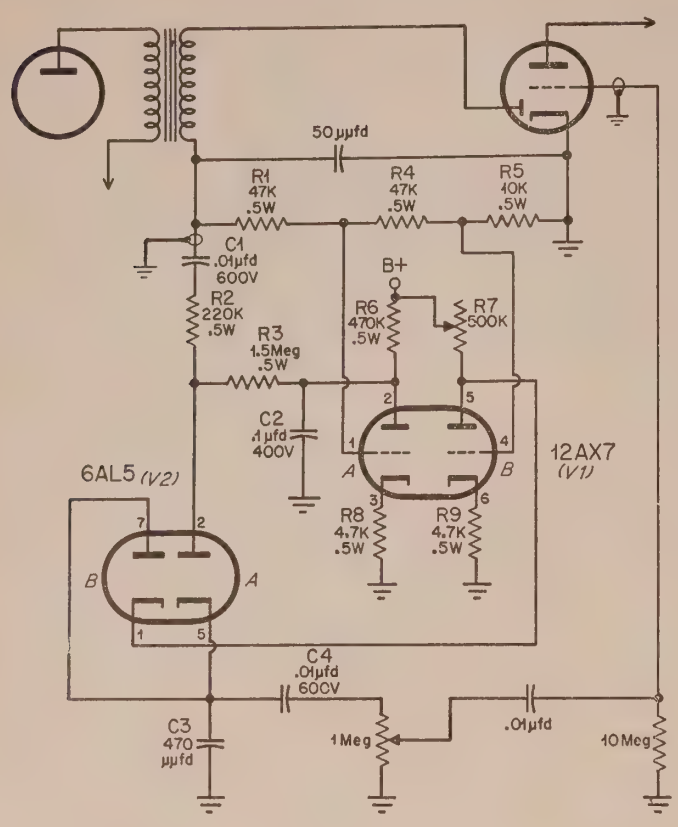


Fig. 4-3-A. Basic TNS circuit.

noise impulse with a steep wave front is received, the grid of *section* B of *V1* will be driven more negative which will cause a rise in plate voltage in *section B* of *V1*. The cathode of *section B* of *V1* is driven more positive than the plate of *section A* of *V2* and the current flow through the limiter tube is interrupted, causing a hole to be puched in the signal. While the grid of *section A* of *V1* receives the same impulse as the grid of *section B*, the plate of *section A* does not follow the noise impulse due to the time constant of the filter components *C1*, *C2* and *R3*. Therefore the plate of *section A* of limiter tube *V2* does not receive the noise impulse in phase with the cathode of *section B* of *V2*. However, the noise impulse is coupled to the plate of *section A* through resistor *R2* and capacitor *C1* and arrives out of phase, which tends to lower the positive plate potential, thus aiding in reversing the polarity between the plate of *section A* and the cathode of *section B* of limiter tube *V2*.

Since the plate potential of *section A* of *V1* varies at an average rate directly proportional to the strength of the incoming signal, the noise limiter threshold is automatically set, and the limiter is effective on all values of modulation.

Adjustment of the variable resistor *R7* will provide a squelch action which is very effective in the suppression of the background noise.

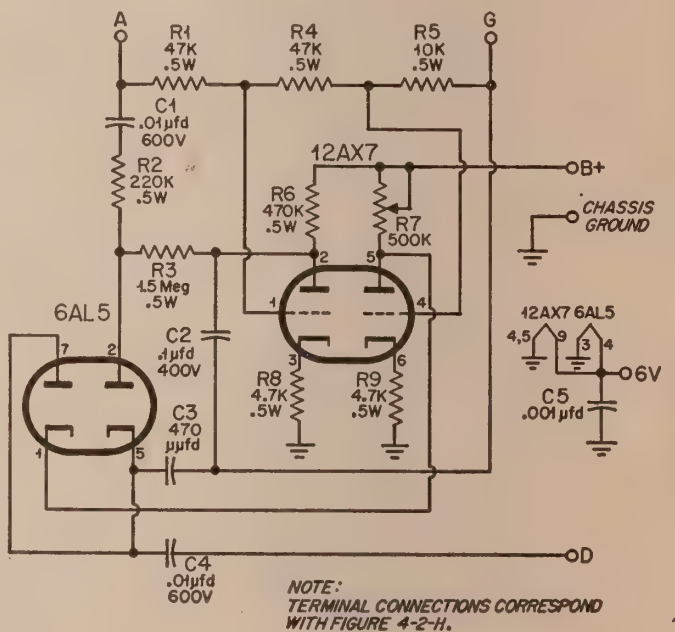
Audio output is taken from the plate of *section B* and the cathode of *section A* of *V2*. Automatic volume control is obtained from the second half of the 6AL5 detector tube.

Construction of TNS

The *TNS* may be built directly into new equipment. However, the greatest interest will be in an auxiliary unit that may be connected to an existing receiver. (See *Fig. 4-3-B*)

The *TNS* unit consists of two tubes, a 6AL5 diode *(V2)* and a 12AX7 double triode *(V1)*. Since these tubes are operating in a high impedance circuit, the input and output leads *(A* and *D)* between the *TNS* and the receiver must be made of shielded cable, such as *Belden 8885*. A filament, ground cathode return *(G)* and B plus lead must also be run to the *TNS*, making a total of six leads, two of them shielded. The shields may be used as the ground return of the unit.

The *TNS* may easily be built in a small metal box measuring 2¼" x 2¼" x 4" such as a *Bud CU-3003*. A *Vector 8-N-9T* turret socket can be used for the 12AX7 as most of the resistors and condensers may be mounted directly on the terminal lugs *(Fig. 4-3-C)*. Since the *TNS* is left permanently in the circuit the only control on the box is *R7*, the squelch level control. This is mounted on the small end of the box, and the two tube sockets are mounted on the 2¼" x 4" side. A *Cinch-Jones* socket *(P306-FP)* is mounted on the opposite end of the box from the squelch control and the six connecting leads are run through this plug and socket. The cable



R1, R4—47,000 ohms, ½w.
R2—220,000 ohms, ½w.
R3—1.5 megohm, ½w.
R5—10,000 ohms, ½w.
R6—470,000 ohms, ½w.
R7—500,000-ohm potentiometer
R8, R9—4700 ohms, ½w.
C1, C4—0.01 μfd., 600v.
C2—0.1 μfd., 400v.
C3—470 μμfd.
C5—0.001 μfd.

Fig. 4-3-B. This is the TNS adapter unit which is designed to work with any automobile radio. The points A, D and G correspond to those shown in Fig. 4-2-H.

leads *A* and *D* which run from this plug must be made of shielded wire.

Installation of the TNS

The *TNS* may be adapted to any conventional receiver by referring to *Fig. 4-2-H*. This illustrates the more common detector circuits encountered in auto radios. Dotted lines are shown for the connections to be removed before insertion of the *TNS*. The existing load resistor should be removed, as shown. Insert the *TNS*, connecting the corresponding points of *Fig. 4-3-B* and *Fig. 4-2-H* together. *Point G* of *Fig. 4-3-B* should be connected at the cathode terminal of the diode socket (the connection point of the old load resistor) even though this point may not be at ground potential, as in the case of certain delayed a-v-c circuits.

Leads *A* and *D* should be each individually shielded throughout the cable run from the *TNS* to the receiver, as well as inside the receiver.

Best operation of the *TNS* is obtained when separate detector and audio tubes are used in the auto radio. When a diode-triode tube is used for both functions, (such as a 6SQ7 or a 6AV6) there may be signal leakage through the common cathode of the tube, resulting in your

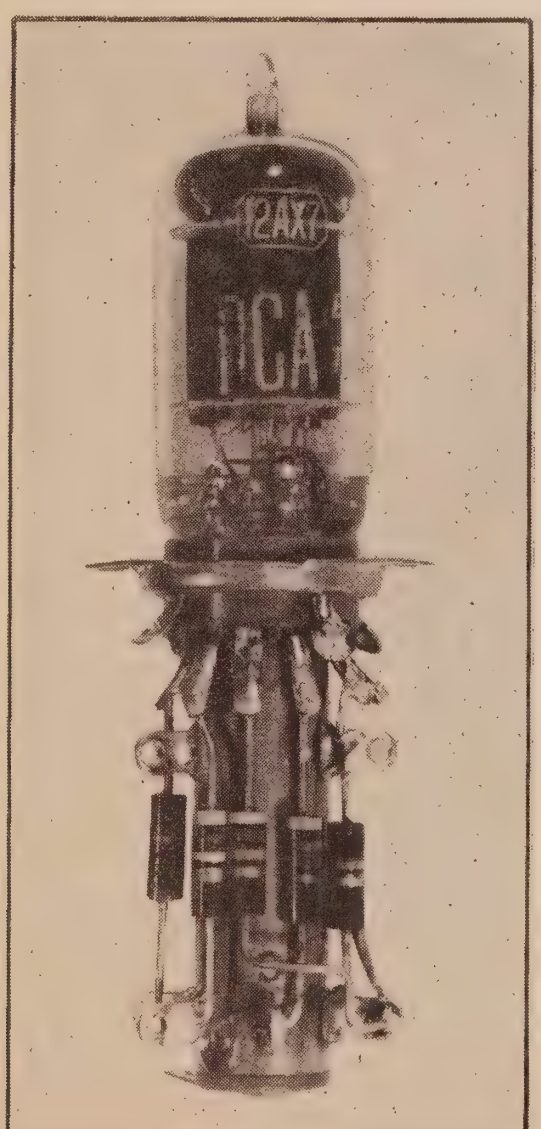


Fig. 4-3-C. In this adapter the major portion of components were mounted on a Vector socket

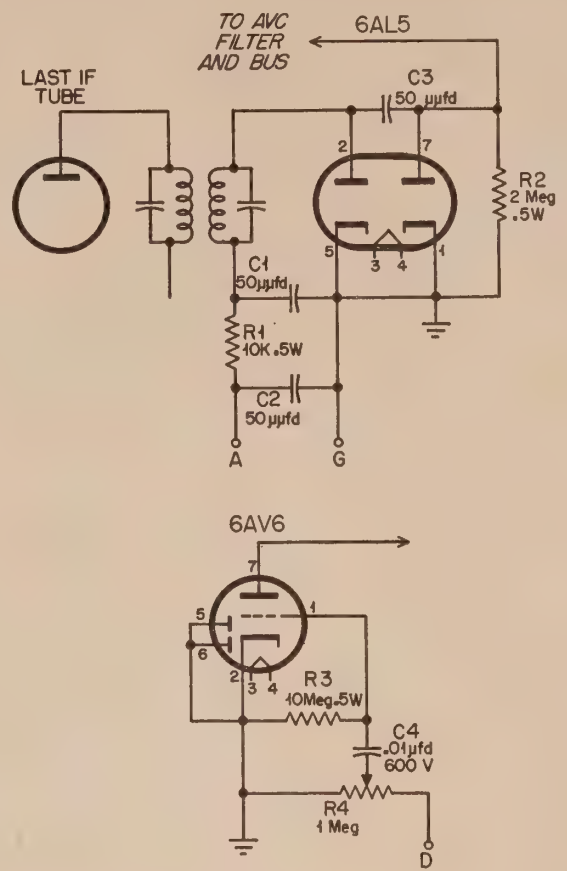


Fig. 4-3-D. This is the recommended second detector and first audio modification in the car receiver to obtain optimum results with the TNS.

own ignition pulses leaking through the silencer. The best detector-audio circuit tried with the *TNS* used a dual-diode as detector and a.v.c., and a separate triode tube as the first audio stage *(Fig. 4-3-D)*. A 6AL5 is used as the diode tube, and a 6AV6 or 6AT6 is used for the audio stage.

The functions of these two tubes may be combined into a single tube, having a double diode and a triode *with* separate cathodes, such as the 6AQ7 (octal base) *Fig. 4-3-E*, or the 6T8 (9 pin miniature), *Fig. 4-3-F*. These circuits are suggested for use when the space will not allow the use of two separate tubes. The present detector tube of the auto radio may be removed and either the circuits substituted for improved performance of the *TNS*.

Notes on the TNS

The *TNS* should be connected to the auto radio, and the squelch action applied by advancing the squelch control until all normal background noise disappears, leaving no sound in the loudspeaker. Tune around the band until a carrier is found, upon which the squelch will automatically trigger, and the carrier and audio component of the signal will be heard in the speaker. Cessation of the carrier will immediately put the squelch in operation and silence the speaker. By backing off on the squelch control to where it rests at a critical level and only a light background noise is barely heard, a weak carrier will trigger the squelch. Under severe

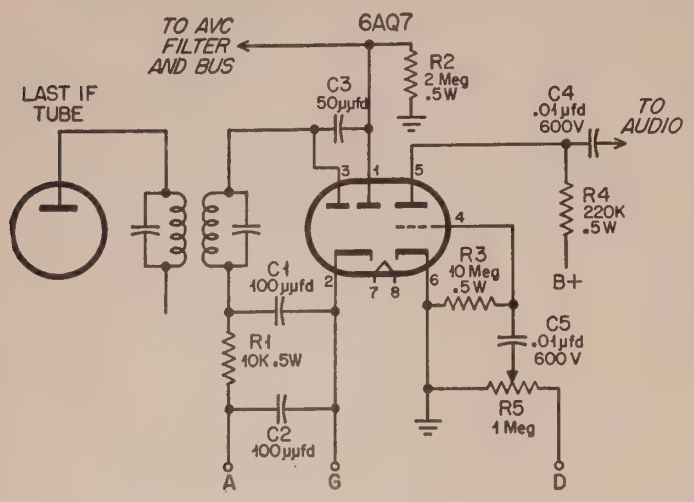


Fig. 4-3-E. Detector and audio circuit for use with the TNS using a single 6AQ7 dual-purpose tube.

noise conditions the *TNS* not only eliminates the background grind, but it also enables one to easily find even a weak carrier—it just pops up out of the background!

As with other noise limiters, the *TNS* requires a fairly high i-f signal level at the detector, and the performance of the noise limiter system will be impaired if the receiver has low gain in the r-f and i-f circuits.

On the other hand, too high a level from the r-f converter will cause overloading on heavy ignition impulses, and the ratio of ignition to r-f signal level will not be handled properly by the a-v-c system.

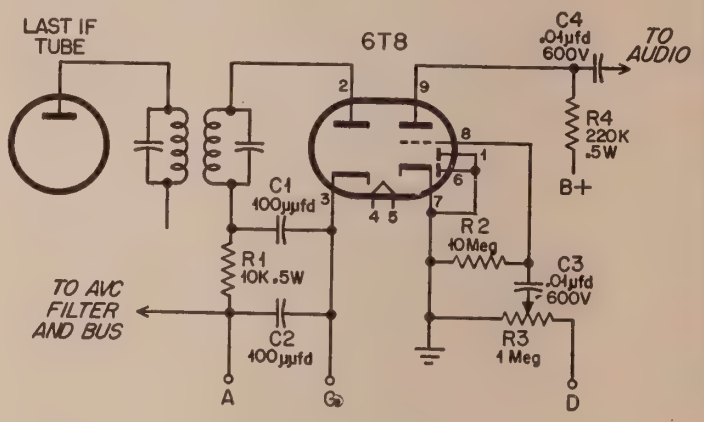


Fig. 4-3-F. Suggested circuitry using the TNS principle with a 6T8 dual-purpose tube.

Chapter Five

Mobile Transmitters

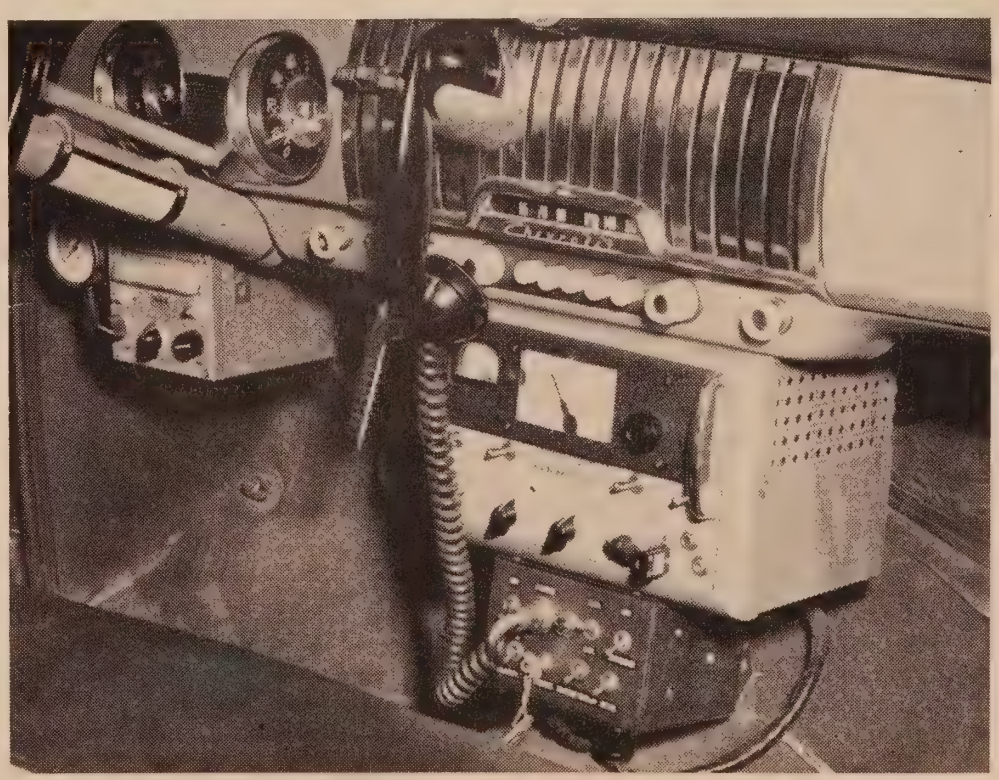
5.1—Basic Requirements and General Design

The mobile transmitter has several distinct properties that tend to set it apart from fixed station equipment:

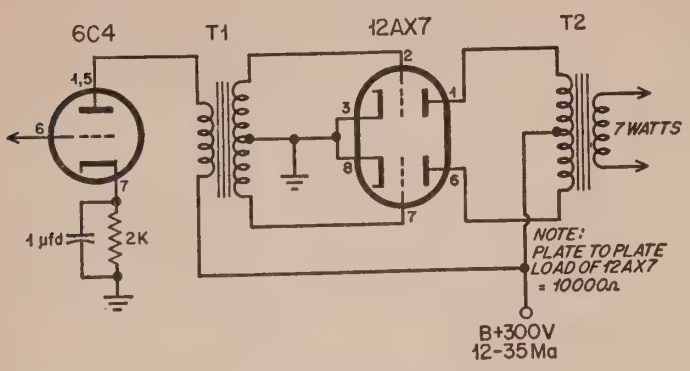
1. Size is an important factor.
2. The transmitter is usually remotely controlled.
3. The transmitter must be so built as to be mechanically shock resistant.
4. The filament voltage is restricted to 6.3 volts or below, except in the case of a few '53 model cars.
5. The control circuits are operated from 6 volts d.c.
6. The filaments may be of the direct heated type.
7. The transmitter is usually designed around the power supply unit.

Points 1. and 2. are self-evident and require no comment. Point 3. is exceedingly important. With the shocks and accelerations usually encountered in an automobile it has been found that the use of shock mounts on the mobile equipment is unnecessary and even undesirable. The equipment should, however, be firmly fastened down to the car frame so that it cannot shift position. Lock washers should be used under all machine bolts, and wiring should be laced. If much rough driving is contemplated, tube clamps should be used. They are not necessary for ordinary city driving. Clean, neat, and mechanically sound assembly, with a goodly amount of common sense built into it is all that is needed for successful construction of mobile equipment.

Points 4, 5 and 6 are directly related to the available primary power source. In some cases,



Mobile installations come in many different size packages. In this photo of W6SXI a Sonar receiver and an Elmac A54 transmitter form the basic units. The receiver is powered from the broadcast receiver while the transmitter derives its power from a Carter 520VS dynamotor. The control box under the transmitter is used for disconnecting the modulators, CW operation, testing and handset control.



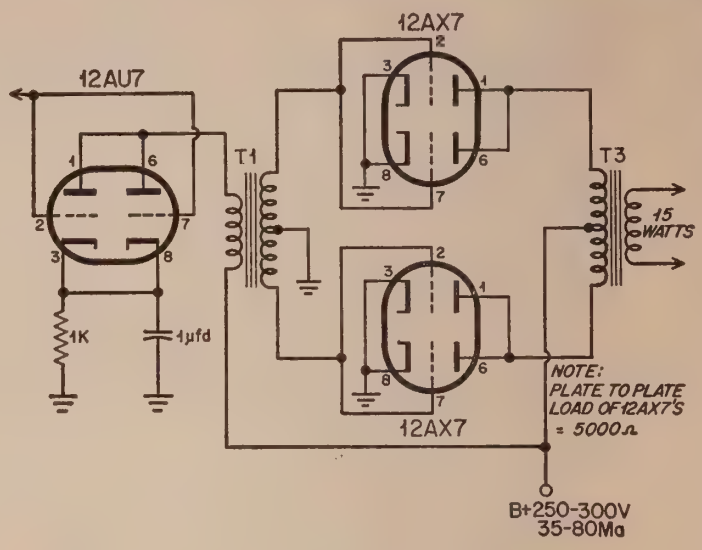


Fig. 5-1-A. The use of either of these two low-powered modulators is to be highly recommended. Transformer T1 may be a UTC S-8. Transformer T2 may be a UTC S-18, and transformer T3 may be a UTC S-19.

where a large percentage of operation is planned when the automobile engine is not running it may be wise to use instant heating filament tubes in the transmitter. These may be turned completely off during periods of reception to conserve battery drain. These tubes are more expensive, more microphonic and more fragile than the indirect heater type which are to be preferred in most cases.

For those cars with 12-volt ignition systems there is a complete series of 12-volt heater tubes, both receiving and transmitting types. The 12-volt 807 pentode, the 1625, is highly recommended for mobile use. It is readily available on the surplus market at a very low price.

The control circuits may be operated directly from the d.c. primary circuit of the car. Operation of these circuits is discussed in *Chapter 2.9.*

Point 7. is extremely important and is often ignored by designers of mobile equipment. The power capabilities of most mobile supplies is strictly limited, and great care must be taken to insure that the transmitter design will work efficiently with the available power supply. For example, let us assume we have a 300-volt, 100-milliampere vibrator-type power supply and we wish to design a transmitter to work in conjunction with this supply, operating efficiently and not exceeding the rating of the vibrator unit.

We may allocate the 100 milliamperes as follows: Oscillator-20 ma. Amplifier-45 ma. Speech amplifier-3 ma. Modulator resting current-20 ma. This gives a total power drain without modulation of 88 milliamperes. Under 100% voice modulation, the modulator plate current would rise to about 45 ma., making the total current drain from the vibrator supply about 113 milliamperes. This is an intermittent drain, the average current being about 100 milliamperes or less with voice modulation. If a large value of output capacity is used in the filter system (10 μfd.) of the vibrator supply the voltage regulation will be satisfactory, as the condenser will absorb the impact of the peaks of current caused by modulation. The power input to such a transmitter would be about 13½ watts. With an amplifier efficiency of 70%, a 100% modulated carrier of 9½ watts would be radiated.

The next step upwards in power would be the use of a dual vibrator supply or dynamotor to supply 300 volts at 200 milliamperes. This power could be apportioned in this manner: Oscillator (and buffer, if one is used)-30 ma. Final amplifier-90 ma. Speech amplifier and driver-20 ma. Modulator resting current-20 ma. This gives us a total current drain without modulation of 160 milliamperes. Under 100% modulation, the modulator plate current would rise from 20 ma. to about 65 ma. on peaks. The total current drain, then, is 205 milliamperes. Again, a large capacity output filter condenser should be used in the power supply. The power input to this transmitter is 27 watts, and the carrier power, assuming the same figure of 70% efficiency is 19 watts. The total primary drain in the first case was about 50 watts of power. In the second case it is about 100 watts. The signal is now 3 db. louder, or about ½ *S*-unit. This is just about the minimum signal change that can be noted on a receiver signal. To gain another 3 db. it is necessary to increase the input to the power amplifier to 55 watts. Let us see what this would entail.

It would be necessary to increase the plate voltage from 300 volts to the region of 400 to 500 volts. This takes us out of the power level of the vibrator supply and puts us into the dynamotor bracket. At this jump we lose approximately 10% power in conversion efficiency, since the dynamotor consumes a fair amount of power just in the mere act of rotating its armature. The popular PE-103A dynamotor will be used for this example. We will draw 250 milliamperes at 450 volts from it: Exciter stages-30 ma. Final amplifier-120 ma. Speech amplifier and driver-20 ma. Modulator resting current-20 ma. This is a total current drain of 190 ma. Under modulation, the modulator plate current will rise to 100 ma. This is a

total drain of 270 ma., well within the conservative rating of the PE-103A. The input to the power amplifier is now 54 watts, and assuming the usual 70% efficiency, a carrier of 38 watts is generated. This is exactly 3 db. louder than the transmitter using the two vibrator supplies and 6 db. louder than the transmitter with the single vibrator supply. Our primary drain from the primary system of the car has increased to 200 watts. It can be seen from these examples that a 3 db. signal increase is bought dearly, costing an additional 100 watts of primary power for each 3 db. above the original 9½ watt carrier.

How much power to run? This is a personal problem, not a technical one. Most amateurs settle for a dual-vibrator supply or a 400-volt dynamotor as the middle course. A single vibrator supply transmitter does not leave the operator much of a margin for error when the carrier is less than 10 watts. Any slight inefficiency in the system will reduce the carrier to a minute value. A carrier of 15 to 25 watts starts to assume respectable proportions and is probably the best compromise between battery drain and transmitter output.

Choice of Tubes

A mobile transmitter is essentially a low voltage, high current device, and proper tubes must be used to meet this limitation, or it will be difficult to load the power amplifier to full input. For inputs under 15 watts the 6AQ5, 6216. 5763, 6V6, 6L6 or 6F6 will work well. These tubes can be loaded to a plate current of 40 to 45 milliamperes easily and without harm. For higher plate currents, at the 300-volt level, it is necessary to parallel two of these tubes, or to use tubes with more filament emission and higher perveance that will permit the use of higher plate current. The 6AV5GT and 6216 are recommended for this use. For 350 to 450-volt operation the 2E26, 807 and 6146 tubes are recommended. The 832 and 829 tubes are excellent, but they are usually too high priced for the average Ham. In their place, the twin-pentode 815 will perform in a very satisfactory manner if sufficient drive is available.

Several practical circuits may be used for modulators to improve the overall power efficiency level. For audio powers of 5-7 watts, a single class B 12AX7 tube works well. Two of these tubes in push-pull parallel connection will generate 15 watts of voice audio at 250 volts *(Fig 5-1-A)*. For 300-volt operation the type 1635 tube is recommended. The 1635 is a special purpose 6N7 double triode that operates with a resting plate current of only 7 ma., compared with a resting plate current of 35 ma. for the 6N7. The socket connections and operating parameters of the 1635 are the same as those of the 6N7. The 1635 may be obtained on the surplus market or on special order through any wholesale dealer.

For operation in the region of 400-600 volts, two 807 tubes class B connected are recommended. The tubes are connected as class B triodes *(Fig. 5-1-B)*. The resting plate current drops from the usual value of 70 ma. to only 20 ma. when the tubes are so connected.

5.2—Modulation Considerations

Because of the relatively low power inputs used with mobile transmitters and the lower efficiency of the antennas compared with fixed stations, the effectiveness of the modulation of a mobile transmitter assumes a high order of importance. (Effective modulation means *enough* of the *right kind* of modulation. For example, one may modulate 100% but have a bassy sounding audio such that 100% modulation occurs at 300 cycles and never at 1000 cycles.)

The frequency spectrum of the human voice may be roughly divided into two regions: The first region contains all frequencies lower than 500 cycles. These frequencies contribute identification to the speaker. They tell whether the

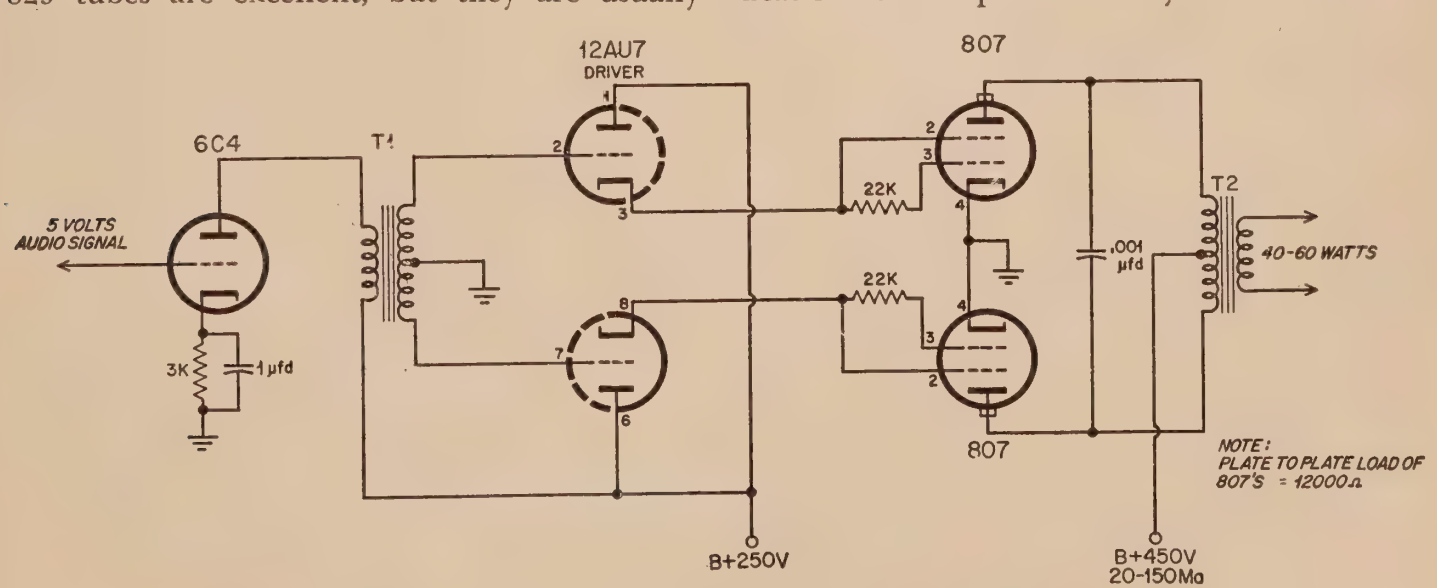


Fig. 5-1-B. This circuit provides more audio at a reasonable value of resting plate current. The 807's are operated as class B triodes. Transformer T1 may be a UTC S-2, while a UTC S-20 will serve as a modulation output transformer.

speaker is male or female and enable one to identify one male voice (or female) voice from another. The second region contains all frequencies above 500 cycles. These frequencies carry the message that is being spoken. A good example of these frequencies is a whisper. Everyone, man or woman, whispers alike. A blindfolded listener finds it almost impossible to distinguish one person's whisper from that of another. When one speaks normally, he is actually still whispering, but he is also adding in lower frequencies which identify his voice. Some readers may recall having seen a demonstration of this by the Bell Telephone Laboratories' VODER, an electronic machine which created speech sounds, and actually could say words and sentences. The only sounds the VODER really made were a hiss, or whisper, and a low frequency buzz. These sounds could be put together by the operator of the machine into understandable speech.

Measurements taken on many male and female speakers show that the maximum energy in speech exists at about 500 cycles. The speech energy drops at a rate of approximately 6 db. per octave above 500 cycles. It is this energy that carries voice intelligibility. Thus a modulation system with a flat audio frequency response may sound natural, but it certainly is not that wanted for maximum intelligibility. Overmodulation will occur first somewhere around 500 cycles, leaving the intelligence carrying frequencies many decibels down from this value.

If all frequencies *below* 500 cycles are eliminated, no loss of intelligence occurs, although we will have thrown away about 65% of the total speech power—the function of this power being only to make the speaker sound natural. When we throw away this "make-natural" power by severely limiting the lower frequencies, we can modulate 4 db. heavier on what frequencies remain—that part which gets the intelligence through! Of course in order to get this "free" 4 db. we must have a modulation system capable of delivering it.

If, in the interests of signal bandwidth, we limit the high frequency response of the system to 2500 cycles, we will lose only about 18% of the syllables, and 3% of the words. Since more loss of words and syllables occurs because of QRM and fading than because of this restricted bandwith, we may consider the cutting of high frequencies to be very desirable.

It was stated previously that the energy in the average voice drops about 6 db. per octave above 500 cycles. If we employ a system that will boost frequencies 6 db. per octave above 500 cycles, maximum modulation will occur at all audio frequencies simultaneously. The 2000-cycle range will actually be 12 db. higher in this system than the same frequencies in a "flat" system.

The last step is to employ speech compression. Peak amplitudes in speech are some 10 db. greater than the average speech power, and since we have made all speech energies equal in our modulation system between 500 and 2500 cycles, compression of peaks will occur equally everywhere along the audio spectrum. We can now compress some 6 db. without harmful effects.

C1—0.005 μfd., ceramicon
C2—100 μμfd. mica
C3, C5—1.0 μfd., 200v.
C4—560 μμfd., mica
C6, C8, C9—0.001 μfd., ceramicon
C7—8 μfd., 450v.
R1—1000 ohms, 1/2w.
R2, R6—47,000 ohms, 1/2w.
R3—100,000 ohms, 1/2w.
R4—220,000 ohms, 1/2w.
R5—1500 ohms, 1/2w.
R7—100,000-ohm potentiometer
R8—750 ohms, 1/2w.
R9—500 ohms, 1w.
T1—UTC #S-8, class B driver
T2—UTC #S-19, 30-watt modulation transformer

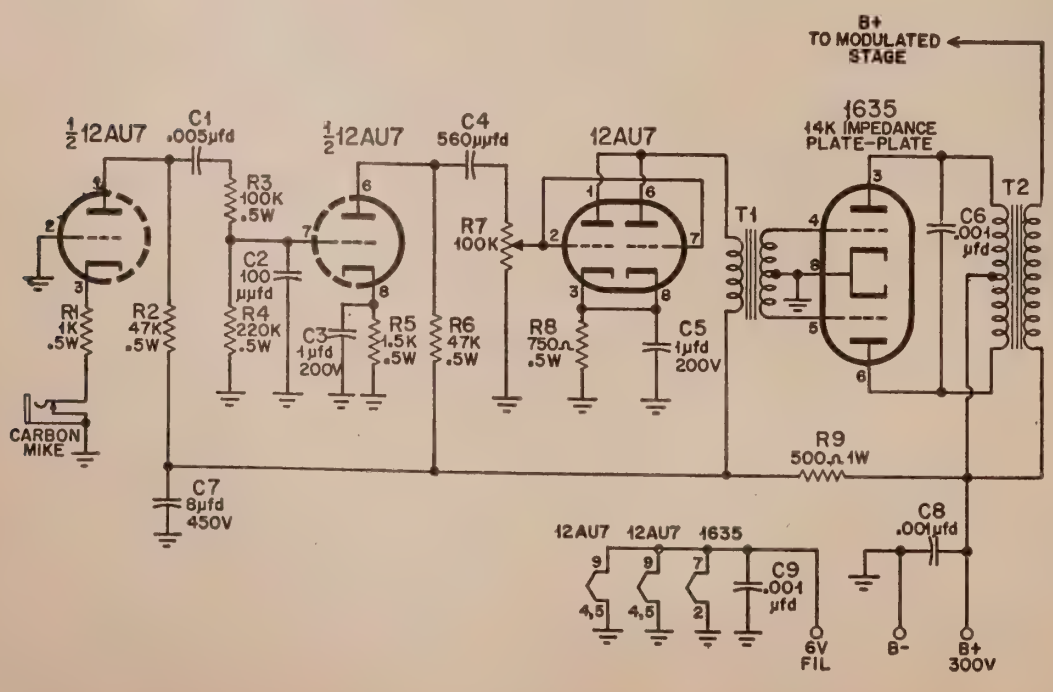


Fig. 5-2-A. This modulator is especially designed to incorporate speech waveforming (attenuation below 500 cycles and above 2500 cycles) with surprisingly low power drain.

A complete modulation system, utilizing all these principles should have:

1. Complete attenuation below 500 cycles.
2. 6 db. per octave boost from 500 cycles to 2500 cycles.
3. Attenuation of all frequencies above 2500 cycles.
4. About 6 db. of speech compression.

This will provide maximum speech modulation effectiveness in a mobile transmitter.

Low Drain Modulator

A circuit incorporating these first three features is shown in *Fig. 5-2-A*. This modulator, using a 400-volt plate supply is capable of modulating 50 watts input to the final amplifier. With a 300-volt supply, it will fully modulate 25 watts input to the final stage. The total modulator plate current drain with no signal input is only 27 ma. This is less than drawn by a single 6N7 tube. For 300-volt operation, the total modulated plate current drain is just slightly over 50 ma. Assuming 50 ma. of current for the r-f section of the transmitter, this rating will allow the use of a single 300-volt, 100-milliampere vibrator supply for 300-volt operation. If a large output condenser is used on the vibrator supply, the slight voice peaks that produce a total plate current of slightly greater than 100 ma. do not cause a sharp drop in plate voltage. At 400 volts the modulated plate current drain is 95 ma. at full output.

Referring to *Fig. 5-2-A:* A dual 12AU7 tube is used as a grounded grid cathode driven stage of speech amplification. The cathode current of the tube provides microphone current for the carbon microphone connected between the cathode bias resistor and ground. The R/C network between the plate circuit of this tube and the grid circuit of the second half of the 12AU7 provides some measure of response shaping. *C1/R3* provides a sloping response characteristic to attenuate the low frequencies, while *R4/C2* attenuates the high frequencies. Condenser *C3* in the cathode of the second section of the 12AU7 also offers some low frequency attenuation.

Network *C4/R7* provides a rising characteristic to the audio response between 500 and 5000 cycles. There is 6 db. boost from 500 to 1000 cycles, 3½ db. boost between 1000 and 2000 cycles, and 1.8 db. boost between 2000 and 5000 cycles. This response, combined with the shaping networks in the first 12AU7 stage provide a very satisfactory speech response. The audio is clear and crisp, and is very effective in cutting through heterodynes and other signals.

The second 12AU7 is connected in parallel to provide a source of power for driving the low impedance grids of the 1635 modulator. Transformer *T1* is a class B driver transformer, with a total step-down ratio of 5:1. Condenser *C5* is chosen to attenuate the audio frequencies below 200 cycles.

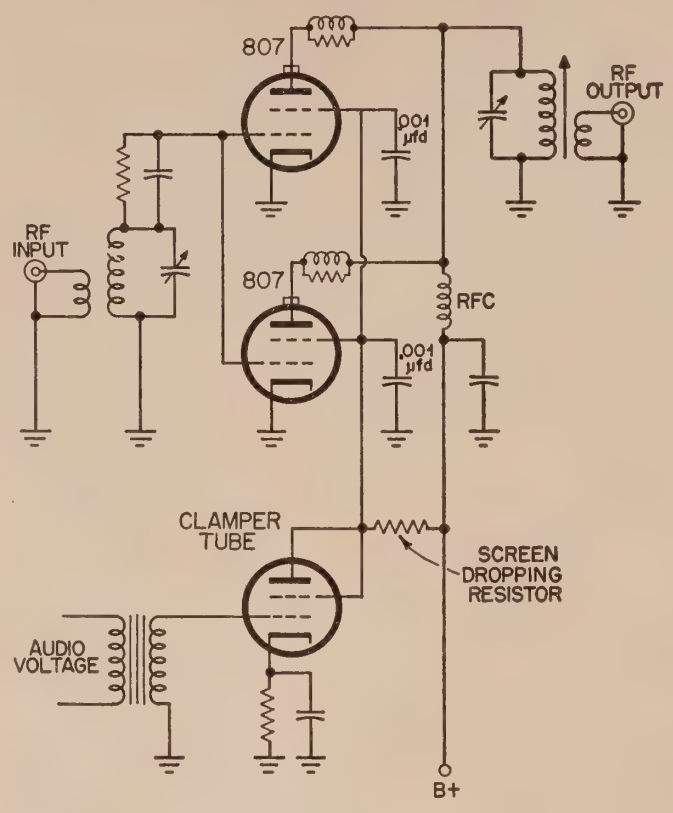


Fig. 5-2-B. This is the basic working schematic of the clamp tube modulating system. The audio wave varies the internal resistance of the clamp tube which in turn controls the screen grid voltage of the r-f stage.

The 1635 tube is an excellent low power modulator. It is a commercial version of the 6N7 tube, having higher voltage and dissipation ratings, and a substantially lower resting plate current with no audio excitation. With voice waveforms, this tube will modulate 50 watts input to the final class C amplifier stage.

Condenser *C6* is connected across the primary of the class B output transformer. In conjunction with the leakage reactance of *T2* and the usual plate-to-ground bypass condenser in the final amplifier, this condenser forms a *pi*-section lowpass audio filter, cutting off sharply at about 4000 cycles.

This modulator will effectively modulate various r-f tubes, such as the 2E26, 807, 6146 and 6AV5.

Screen Modulation

Since pentode tubes are in almost universal use in the modulated stages of mobile transmitters, it is natural to think of some form of screen modulation as an economical means of obtaining the maximum carrier power from the available primary power source in the car. Since screen modulation does away with the heavy current drain needed by a class B modulator, it is an important type of modulation to be considered when designing mobile transmitting equipment.

Among the low power tubes, the 807 is one that is well suited for screen modulation. It can be modulated close to 100% with a suitable

screen modulation system. It has a rather high impedance (high voltage, low current) screen circuit and requires but little audio for modulation. Other tubes with low impedance screen circuits (such as the 6146) are not as well adapted to screen modulation as is the 807.

The most widely used system of screen modulation is the so-called "clamp-tube" system. It derives its name from the use of a screen clamper tube as a Heising modulator for the screen circuit of the r-f stage *(Fig. 5-2-B)*. Audio voltage is supplied to the grid of the clamp tube, and the internal resistance of the clamp tube varies at an audio rate. This varying resistance is placed in parallel with the resistance to ground formed by the screen grid circuit of the modulated stage. With a tube of high screen resistance and a large value of series dropping resistance, the varying resistance of the clamp tube has a very decided control on the voltage drop across the series resistance, and consequently the voltage applied to the screen of the tube. But with tubes of low internal screen resistance, the current is higher and the value of the series dropping resistor is lower and the control of voltage by the clamp tube is less effective.

A suitable circuit for modulating one or two 807 tubes is shown in *Fig. 5-2-C*. The 6SN7 acts as a matching tube for a carbon microphone, and a single stage of transformer coupled speech amplification. The 6L6 tube acts as the "clamper tube" modulator. In order to obtain a high percentage of modulation it is necessary for the 6L6 to swing the screens of the 807 tubes to zero voltage. Since the instantaneous plate voltage of the 6L6 never swings as low as zero volts, it is necessary to add the *R6/C4* circuit between the 6L6 and the 807 screens. *C4* will hold the d.c. voltage constant under modulation, while *R6* allows the instantaneous screen voltage of the 807 tubes to drop to zero under modulation peaks, when the 6L6 plate voltage is at its lowest point.

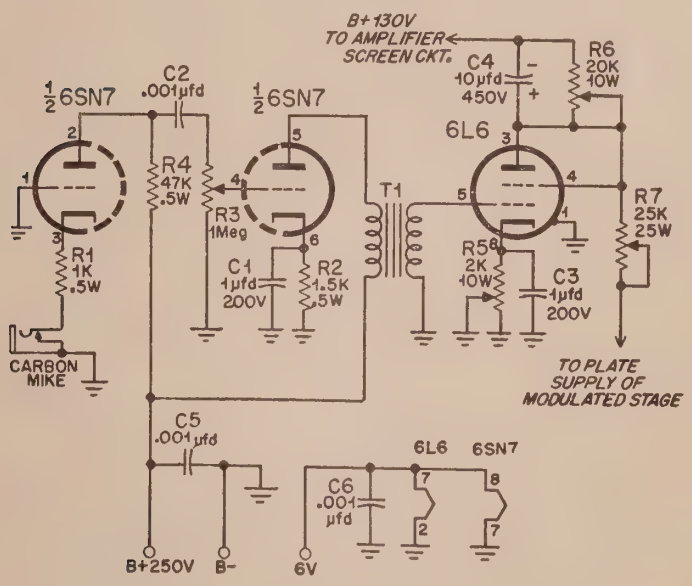


Fig. 5-2-C. A clamp tube modulator capable of controlling the screen voltage of one or two 807 tubes.

C1, C3—1.0 µfd., 200v.
C2, C5, C6—0.001 µfd., ceramicon
C4—10.0 µfd., 450v.
R1—1000 ohms, ½w.
R2—1500 ohms, ½w.
R3—1.0 megohm potentiometer
R4—47,000 ohms, ½w.
R5—2000 ohms, 10 watts, adjustable
R6—20,000 ohms, 10 watts, adjustable
R7—25,000 ohms, 25 watts, adjustable
T1—3:1 interstage

Screen modulation is essentially a high voltage, low current system, and this system works best when 700 to 1000 volts are applied to the plates of the 807's. The minimum plate voltage for efficient clamp tube modulation of 807 tubes is about 450 volts. This is the usual plate voltage obtainable in mobile work, and this system will work in a satisfactory manner with that voltage, but not with any lower voltage.

For best modulation, the coupling to the antenna system should be very tight, and less grid drive is desirable than with plate modulation. With the usual amount of light antenna coupling, downward modulation will be noticed on an antenna ammeter.

To adjust this system, *R7* should be set so that the plate voltage on the 6L6 is about 250 volts. *R6* should then be set so that the 807 screen voltage is about 130 volts. The higher the plate voltage, the greater can be the value of *R7* and the more effective is the modulation system. *R5* is adjusted for 20 volts bias on the 6L6 clamper tube.

After these adjustments have been made, the coupling between the modulated stage and the antenna should be increased past the point of greatest current until the antenna current drops about 15% in value. After this is done, the antenna current will kick up in a lively fashion under modulation.

Gating Modulation

A superior type of "clamp tube" modulation is the *gating system,* wherein the clamp tube is a series connected element in the screen system, rather than a parallel connected element. The control tube now becomes a gate, or variable resistance having a very high internal resistance when no signal is applied to its grid, and becoming lower in value when a signal voltage is applied. A typical circuit is shown in *Fig. 5-2-D*. The modulator load resistance is now in the cathode circuit of the control tube. Such a cathode follower requires a large amount of grid excitation voltage, and it is necessary to drive this stage with a transformer coupled voltage amplifier.

When the audio voltage is applied to the grid of this modulator, the positive peaks overcome some of the bias and the resistance of the tube is lowered and the screen voltage is raised. On negative peaks of audio the reverse takes place and the screen voltage becomes lower.

Since the full screen voltage is applied to the cathode of the modulator, this circuit should not be used where the screen potential exceeds 300 volts or so. Fortunately, most screen grid tubes in mobile service take much less screen voltage than this for proper modulation.

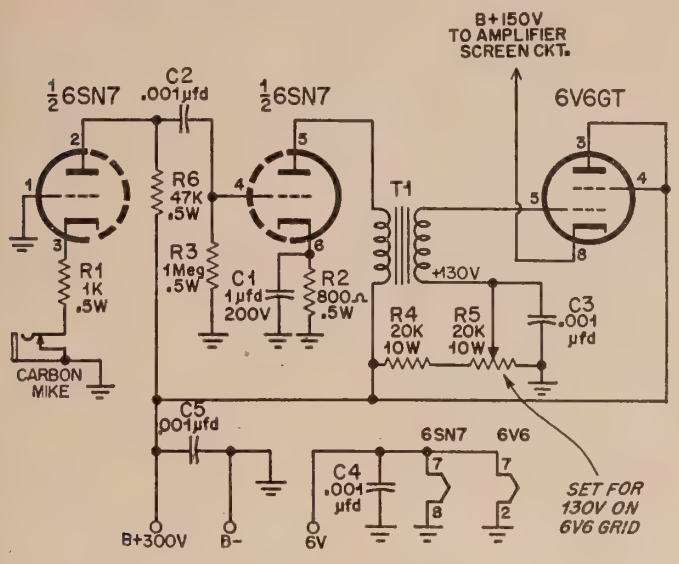


Fig. 5-2-D. The "gating system" is a superior type of screen modulation. The control is effectively used as a gate or series element rather than a parallel variable resistance as shown in Fig. 5-2-B.

C1—1.0 µfd., 200v.
C2, C3, C4, C5—0.001 µfd., ceramicon
R1—1000 ohms, ½w.
R2—800 ohms, ½w.
R3—1.0 megohm, ½w.
R4—20,000 ohms, 10 watts
R5—20,000 ohms, 10 watts, adjustable
R6—47,000 ohms, ½w.
T1—UTC #S-2, 4:1 step-up

Control *R5* sets the initial screen voltage on the modulated stage. If the d-c screen voltage is set low, a definite controlled carrier effect can be noticed. This is most pronounced when a high value of plate potential is applied to the screen grid stage.

The circuit shown in *Fig. 5-2-D* will fully modulate a pair of 807 tubes with 450 to 1000 volts on the plates. The plate voltage on the 6V6 should be of the order of 300 volts. *R5* should be set for a cathode voltage of 150 volts from *pin 8* of the 6V6 to ground. If this voltage is set lower than this, the controlled carrier effect will be noticed, with both plate current and antenna current kicking up under modulation. With 150 volts on the screens of the 807 tubes, there is little if any controlled carrier effect.

As with any type of screen grid modulation, the antenna should be tightly coupled to the modulated stage. Increase the antenna coupling and decrease the grid drive until the antenna current drops about 15% from maximum value. If this is not done, downward modulation will result and the modulation will sound "washed out."

With this, or other types of grid or screen modulation, the over-all efficiency of the modulated stage will be of the order of 35%-40%.

Carrier Control Systems

Screen grid modulation is a form of "efficiency modulation." This means that the peak modulated power in the carrier is supplied by the modulated stage, and that it is not supplied from a separate source, such as class B modulator. The consequence of the peak modulated power (the sideband power) being supplied by the modulated stage is that this stage must *not* be operating at maximum output when there is no modulation. The state of maximum output has to be saved for the condition of 100% modulation. Under 100% modulation, the peak power has to be (by definition) four times the carrier power, it therefore follows that the maximum unmodulated carrier that can be generated is one-quarter the maximum output of the tube.

The peak efficiency of the modulated stage may approach 80% at the best. The carrier level efficiency, therefore, is about 35%-40%, *never more*. If the efficiency of a grid modulated stage is pushed above this point, the modulation becomes lop-sided and the peaks flatten out with resulting distortion and sideband splatter. Thus, the actual output from a given tube is limited by the amount of dissipation the tube must withstand during periods of no modulation. During modulation, the efficiency of the tube improves and it actually dissipates less power than during the periods of no modulation.

Many attempts have been made to "get something for nothing" with screen modulation systems, with the idea in mind of boosting the efficiency of the modulated stage, and obtaining greater than 35-40% efficiency. The only technically correct step in this direction is the use of some form of carrier control whereby the resting carrier may be dropped in value (or, to state the same thing another way the modulated carrier may be boosted to a high value compared to the unmodulated carrier). There are two practical systems that will allow this to be done: the "constant modulation" system derived by W8YHR, and the "Rothman Modulation" system derived by W5PJI.

The Constant Modulation System

The *constant modulation* system is a combination of screen grid modulation and carrier control, whereby only enough carrier is transmitted to provide distortionless detection at the receiver for the amount of sideband power transmitted. The percentage of modulation is always high, and the carrier transmitted is proportional to the audio level. Under conditions of no modulation, there is little or no carrier transmitted. The modulated tubes only work during periods of modulation, consequently they can be driven harder to produce more signal than the same tubes would produce under ordinary grid modulation conditions. The power consumption is low, since the modulated tubes only draw power and produce a carrier under conditions of modulation.

The dual objectives of modulation and carrier control may both be achieved by correct manipulation of the d.c. and audio voltages applied to the screens of the modulated amplifier.

Figure 5-2-E illustrates a typical *constant modulation* system, applied to two 807 tubes in the modulated r-f amplifier.

Under operating conditions, the screen voltage is derived from the rectified audio voltage. No audio voltage—no screen voltage, and no carrier. When audio voltage is developed, it is rectified by a full-wave rectifier (*V1*) and filtered by an L/C network. This filtered voltage is applied to the screens of the 807 tubes, varying the screen voltage and power input to the modulated stage at a syllabic rate. The audio voltage is also applied to the 807 screens, through transformer *T1*.

The plate current of the 807 stage remains at a low value with no modulation, kicking up to some 100 ma. under voice modulation peaks. On peaks, this stage can run up to twice the input that could be run as a plate modulated stage. *But* to reach this maximum state, the plate voltage on the 807 tubes must be approximately twice the class C service plate voltage. This means a minimum of 1000 volts. The product of the plate voltage times the peak plate current using *constant modulation* will just equal the peaks of modulated voltage and current of the class C stage. This requirement of extremely high plate voltage just about rules out any form of efficiency modulation for mobile service, since the systems are marginal in operation at plate voltages of 450 volts or so. Higher plate voltages might be obtained, however, by connecting the secondary windings of two high voltage dynamotors in series.

To tune up a *constant modulation* system, it is necessary to disconnect the screen control circuit, and to temporarily connect the screen circuit to a d.c. source of power. The plate voltage to the modulated stage should be dropped to ½ the operating value. The 807's should be loaded to about 25 watts input (400 volts at 60 ma.) and are then switched over to the *constant modulation* conditions. Plate current will drop to about 15 ma., and rise to about 100 ma. when modulation is applied. Power output is controlled by the audio level to the modulator.

The Rothman Modulation System

The *Rothman Modulation* system, like the *constant modulation* system is a combination of screen grid modulation and carrier control. Instead of deriving the d.c. screen voltage from the rectified audio voltage, the *Rothman* system obtains the screen voltage by rectifying and filtering a sample of the transmitted carrier. With no audio signal applied to the modulator there is no bias applied to the modulator stage and little, if any, screen voltage applied to the final amplifier *(Fig. 5-2-F)*. With low screen voltage there is practically no r.f. output from the modulated stage. When an audio signal is applied to the modulator stage, bias for the 6CD6 tube is developed across *R6*, and the 6CD6 shunt internal impedance rises, applying rectified d-c voltage to the screens of the modulated stage. The output of the modulated stage is rectified by the 6X5 tube and filtered by *C4* in the cathode of the 6X5. The carrier increases with the increase in rectified d.c. voltage applied to the screens by the action of the 6CD6 tube.

In general, the modulated tube must be chosen for relatively low plate impedance and small screen power requirements. The control tube should also be of low impedance in order that it may provide good control action at low screen voltage. As with all efficiency modulation systems, a high value of plate voltage should

C1—0.2 μfd., 400v.
C2, C4—1.0 μfd., 200v.
C3, C5, C6—0.001 μfd.,
R1—100,000 ohms, 1w.
R2, R3—20,000 ohms, 10 watts
R4—220 ohms, 1w.
R5—47,000 ohms, ½w.
R6—1.0 megohm potentiometer
R7—800 ohms, ½w.
R8—1000 ohms, ½w.
T1—Merit #A-3104, 15-watt modulation transformer
T2—Merit #A-2910, interstage
Ch1—Merit #C-2977 choke, 4.5h., 50 ma.

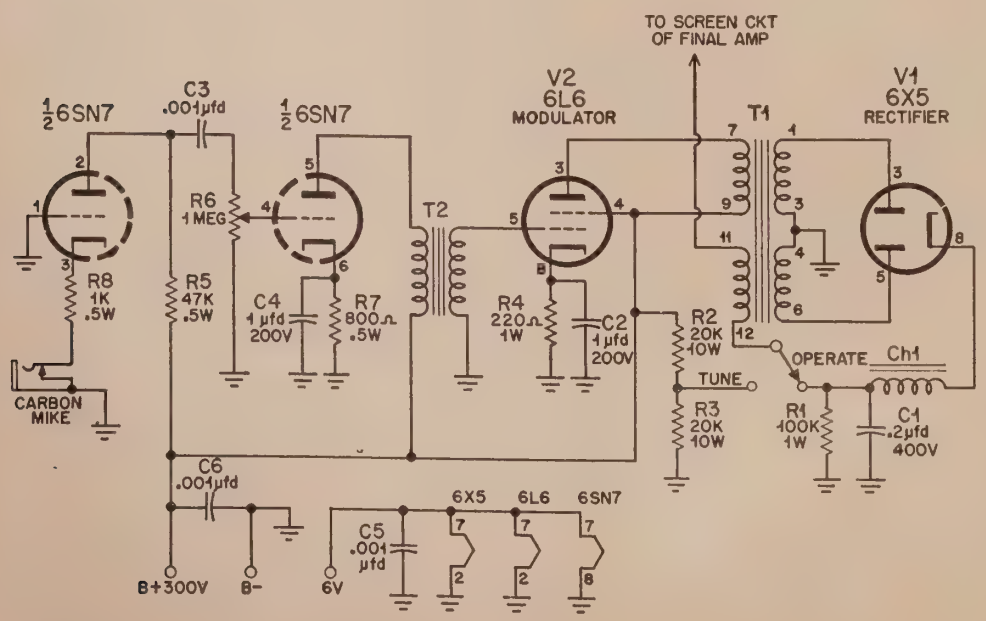


Fig. 5-2-E. The "constant modulation" system was developed by W8YHR and is a combination screen grid and carrier control method. The circuit above could be used to modulate the final r-f amplifier in Fig. 5-2-B.

be used with the *Rothman* system. However, proper choice of low impedance tubes makes it feasible to design a system operating at conventional voltages. The 6CD6, 6BQ6 and 6BG6 are typical tubes which will meet the above requirements.

To adjust a *Rothman Modulation* system, plate voltage to the modulated stage should be at least 1½ times the plate modulated value. Screen feedback under full modulation conditions should be adjusted to produce ½ the rated screen voltage (125 volts for 807's) for the plate modulated condition. Resonance adjustments should be made with the modulator out of the circuit and normal screen voltage applied to the modulated stage. As opposed to conventional systems, the *Rothman* modulated stage draws maximum plate current at resonance, since no screen voltage is developed under off resonance conditions. Care must be exercised not to exceed optimum screen feedback, since this will decrease the plate efficiency of the modulated stage.

The correct tuning procedure is to start with insufficient coupling to the rectifier circuit and gradually increase it until the desired input power is obtained or until a decrease in antenna current is noted. Should this point be reached before desired plate input is obtained, an increase in plate voltage is indicated. Thus the degreee of output coupling to the r-f load affects the amount of energy in the plate tank and therefore the rectifier link adjustment. These two adjustments are independent, and must both be adjusted for the optimum working point. As with any screen modulation system, an oscilloscope is a necessary instrument for the operator to obtain the correct operating parameters.

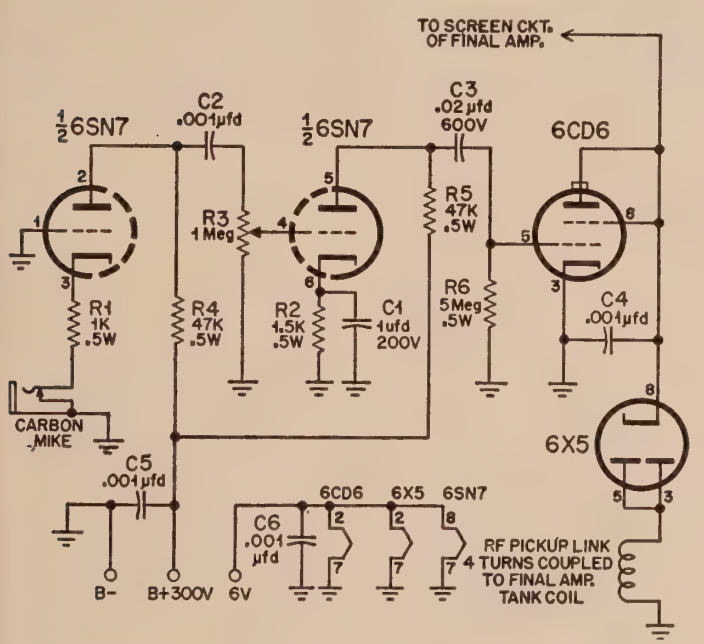


Fig. 5-2-F. A variation of the "constant modulation" system is shown above. Perfected by W5PJI it uses rectified r-f voltage to achieve control of the final amplifier.

C1—1.0 µfd., 200 volts
C2, C4, C5, C6—0.001 µfd., ceramicon
C3—0.02 µfd., 600 v.
R1—1000 ohms, ½w.
R2—1500 ohms, ½w.
R3—1.0 megohm potentiometer
R4, R5—47,000 ohms, ½w.
R6—5.0 megohm, ½w.

5.3—Speech Clipping

By employing speech clipping in mobile transmitting equipment a higher average percentage of modulation is possible without sideband splatter. This is of tremendous advantage in mobile work for the mobile transmitter is usually of low power, and the mobile signal is often much weaker than an equally powered signal from a fixed station. By limiting the frequency response of the modulator and keeping the average level of modulation as high as possible, the mobile station is able to hold its own among signals that are many times stronger.

With a complex waveform, such as that of the human voice, 100% modulation of the carrier is determined by the amplitude of the maximum peaks of the voice wave. These peaks occur at various intervals during speech and result in an *average* modulation level much less than 100%. The peaks are generally composed of vowels which contribute little to speech intelligibility, while the important consonants of less energy are down in the average level. The average modulation level is usually about 25%-35%, depending upon the characteristics of the particular voice, the microphone, and the speech amplifier. This means that the average power is far less than the "four times" carrier peak power attainable at 100% modulation. If the maximum peaks are suppressed or clipped, the amplifier gain control may then be advanced so that the average level containing the vital speech sounds will be increased without exceeding 100% modulation, and the carrier will be better utilized. Thus a stronger audio signal of greater intelligibility for cutting through QRM will be realized.

Clipping creates a certain amount of distortion dependent upon the degree of clipping. In practice, 10 db. or so is a maximum usable amount, as distortion becomes objectionable above this value.

In order to prevent the high frequency harmonics created by the clipping process from modulating the carrier and causing sideband splatter, a low-pass filter should be installed following the clipping stage. This filter should cut off at about 3500 cycles, permitting ample audio frequencies for voice transmission, yet limiting excessive high frequency response. Speech clipping may be done in the low power speech amplifier stages preceding the modulator, or it may be done between the modulator and the modulated amplifier. The latter process is usually employed in mobile work, since the problem of phase shift caused by low level clipping is usually accentuated by the physically small transformers used for mobile equipment.

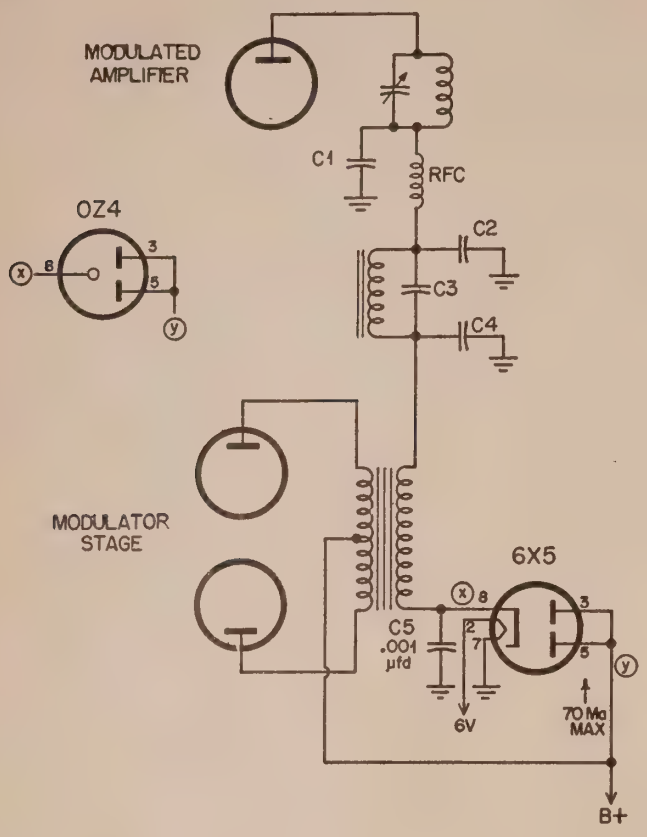


Fig. 5-3-A. High level speech clipper and filter suitable for mobile use. An OZ4 tube may be substituted for the 6X5 when the plate voltage and current are high (Fig. 5-12-B).

High Level Clipping

The circuit for a typical high level clipper suitable for mobile use is shown in *Fig. 5-3-A*. This type of clipper is fully automatic in operation, and will allow extended positive modulation peaks while fully limiting the splatter-causing negative modulation peaks. Condensers *C1, C2, C3,* and *C4* in conjunction with choke *L1* form a low-pass filter, attenuating all frequencies above 3500 cycles. The inductance of the modulation transformer secondary winding, plus *C4* and *C5* form an additional constant-*K* section low-pass filter, giving additional attenuation to the unwanted frequencies.

The clipper tube is placed on the B plus side of the modulation transformer. As can be seen from the circuit, there is a potential difference of about 400 volts between the cathode of the 6X5 clipper tube and its filament, one side of which is at ground potential. The maximum operating potential of the clipper tube, therefore, is the maximum cathode-heater potential at which the tube will operate safely. For the 6X5 tube, this potential is 450 volts. If the clipper tube is placed between the modulation transformer and the modulated r-f stage, the plate voltage of the transmitter would have to be dropped to 225 volts, since under 100% modulation the cathode-heater potential would reach twice the operating plate voltage, or a value of 450 volts. When the 6X5 is placed *before* the modulator, it operates in the identical fashion, *except* that the cathode-heater potential is equal to the operating plate voltage under 100% modulation. Thus the plate voltage to the transmitter may safely be raised to 450 volts, the maximum cathode-heater voltage rating of the 6X5.

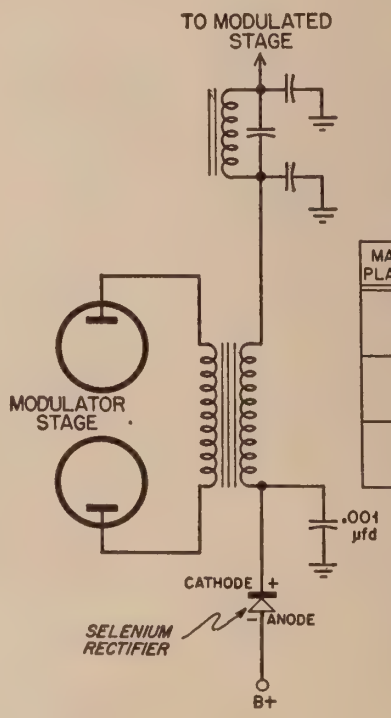
The 6X5 will safely pass a plate current of 70 ma. For currents up to 124 ma., a 6AX5 tube may be used. For greater plate currents, two tubes in parallel should be used.

For plate voltages above 350 volts, an OZ4 gas rectifier may be used. One of these tubes will safely pass 75 ma., and since it has an ionically heated cathode that operates "above ground" *(Fig. 5-3-A)* there is no danger of internal breakdown within the tube. Two or more OZ4 tubes may be used in parallel for greater current capacity provided a 100-ohm 1-watt resistor is placed in series with the anode of each tube to equalize the current through the tubes. The OZ4 tube cannot be used at operating potentials of less than 325 volts, since it takes this voltage to "fire" the tube and start it operating.

For plate voltages up to 1200 volts, it is possible to use selenium power rectifiers at high level clippers. The selenium rectifiers should be insulated from ground to prevent voltage breakdown. Suitable rectifiers are listed for various current ratings in *Fig. 5-3-B*.

The High Level Filter

The usual high level filter is a *pi*-section filter composed of a choke of from 0.1 to 1.0 henries inductance and condensers of from 0.005 µfd. to 0.015 µfd. capacitance *(Table 5-3-A)*. It must be remembered that the plate bypass condenser of the modulated stage is in parallel with condenser *C2*. The plate bypass condenser may be made to act as *C2* by making it the correct value for the filter. Special "splatter chokes" are made by *Chicago Transformer Co., Thordarson Mfg.*



MAX. CLASS C PLATE CURRENT	MANUFACTURER
75	SELETRON 5M4 FEDERAL 1014A
150	SELETRON 6P2 FEDERAL 1029A
300	SELETRON 6QS2 FEDERAL 1022

Fig. 5-3-B. Selenium rectifiers may also be used as high level clippers. One rectifier may be used for plate voltage up to 400 volts. Two in series should be used for plate voltage from 400-800 volts.

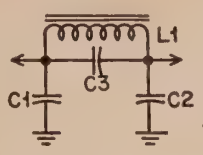


PLATE LOAD (OHMS)	C1,C2 (μfd)	L1 (HENRIES)	C3 (μfd)
2500	.015	0.18	.011
3000	.013	0.21	.01
3500	.011	0.25	.0085
4000	.009	0.27	.007
4500	.008	0.30	.0062
5000	.007	0.38	.0055
5500	.0066	0.42	.0052
6000	.0062	0.47	.0047
6500	.006	0.50	.0043
7000	.0055	0.54	.004
7500	.005	0.58	.0038

Table 5-3-A. This table will enable a high level filter to be designed for 3000 cycle cutoff with various plate loads.

Co., Standard Transformer Corp., and others that have a tapped winding to cover the above inductance ranges. The condensers used in the filter should have a d.c. working voltage rating of three times the unmodulated plate voltage of the transmitter. The correct values of capacitances and inductance for the filter are shown in *Table 5-12-A.*

5.4—A 12AX7 Modulator

The miniature 12AX7 tube makes an excellent class B modulator for low powered mobile transmitters. Operating with a plate potential of 300 volts, the 12AX7 requires no bias, having a resting plate current of only 10 ma. This is lower than any other tube capable of producing the same amount of audio power. The resting plate current of the 6N7 is 35 ma., and the resting plate current of the 1635 is 11 ma. The popular push-pull 6AQ5 modulator draws a minimum plate current of 70 ma. when the stage is over-biased.

When mobile operation is contemplated using a single vibrator supply, it is of the utmost importance that unnecessary current drain be cut to an absolute minimum. The use of the 1635 or the 12AX7 as a modulator is almost mandatory.

The 12AX7 will deliver 7 watts of voice audio with negligible distortion when operating at a plate potential of 300 volts. The resting plate current is 10 ma., rising to about 35 ma. under modulation peaks. The 12AX7 may be easily driven by a single 12AU7. The first half of the 12AU7 is connected as a voltage amplifier, with a carbon microphone in the cathode lead. The second section of the 12AU7 is a transformer coupled driver for the 12AX7. The total plate current drain of the two tubes is 43 ma. when delivering 7 watts of audio (*Fig. 5-4-A*).

Two 12AX7 tubes may be used in push-pull parallel to obtain 15 watts of audio power (*Fig. 5-4-B*). More drive is needed for this circuit, so the 12AU7 driver tube is connected as two transformer coupled stages, the carbon microphone being connected in the cathode of the first section of the 12AU7.

The correct load impedance for a single 12AX7 is in the vicinity of 14,000 ohms. Two tubes connected in push-pull parallel require a load impedance of 7,000 ohms.

Because of the simplicity of these circuits, it is difficult to do much voice wave forming of the response characteristics of the modulator. A drop in low frequency response can be made by

C1—1.0 μfd., 200v.
C2, C3, C4—0.001 μfd., ceramicon
R1, R2—1000 ohms, ½w.
R3—500,000-ohm potentiometer
T1—Merit #A-2910 interstage transformer
T2—UTC #S-8, class B driver transformer
T3—UTC #S-18, 15-watt modulation transformer

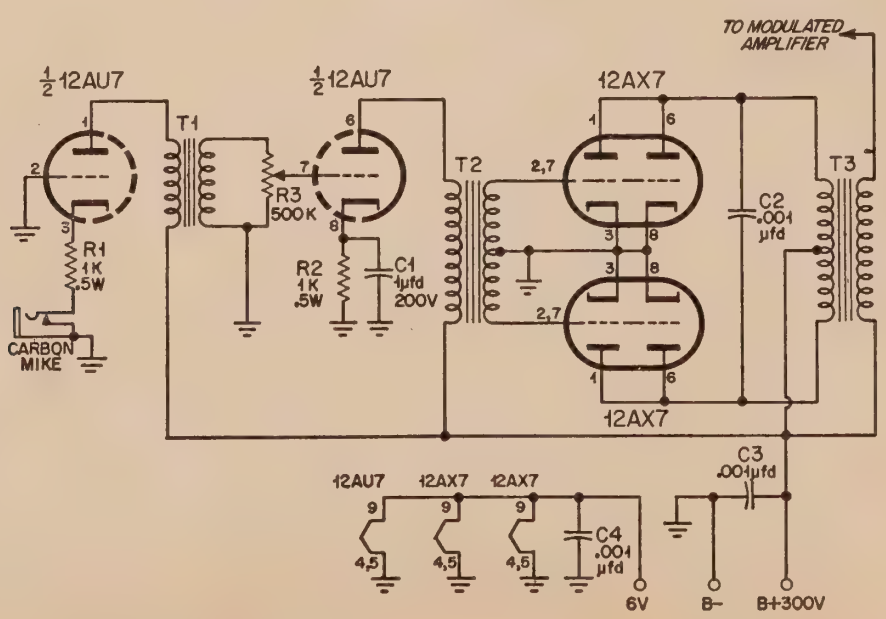
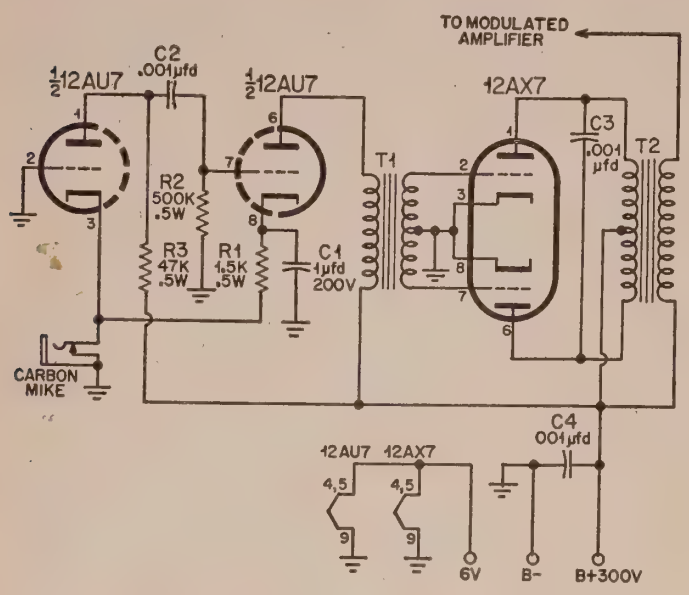


Fig. 5-4-B. For 15 watts of audio the circuit of Fig. 5-4-A may be modified into a push-pull parallel amplifier.



C1—1.0 µfd., 200v.
C2, C3, C4—0.001 µfd., ceramicon
R1—1500 ohms, ½w.
R2—500,000 ohms, ½w.
R3—47,000 ohms, ½w.
T1—UTC #S-8, class B driver transformer
T2—UTC #S-18, 15-watt modulation transformer

Fig. 5-4-A. This very simple modulator using the 12AX7 will deliver 7 watts of audio. It features a resting plate current of only 10 ma.

setting the value of the coupling condenser *C2* in *Fig. 5-4-A* at .001 µfd. The high frequencies are cut sharply by *C3* acting in conjunction with the leakage reactance of *T2* and the plate bypass condenser of the modulated amplifier.

In *Fig. 5-4-B* the low frequency response it controlled by *C1* and by the loss of low frequencies caused by the 12AU7 plate current flowing through the primary winding of *T1*. High frequency response is controlled by *C2* connected across the primary winding of *T3*.

The octal based 6SN7 may be substituted for the 12AU7, and the 6SL7 may be substituted for the 12AX7.

5.5—A 28 Watt 28 Mc. Phone Transmitter Designed by W6WYA

This miniature 10-meter phone transmitter is small enough to be placed in the glove compartment of many cars. Complete with tubes, transformers, and send-receive relay it weighs 3½ pounds. It measures 3½" x 6¼" x 4¼", and draws a minimum of plate and filament current. Although designed for 10 meters, the circuit may be modified for other bands.

The transmitter uses three miniature tubes plus a 2E26 beam pentode in a simple, yet complete circuit. It is crystal controlled, and there is no doubling in the class C modulated stage. The transmitter operates on a.c. or d.c., which enables it to be moved about and used as a portable mobile transmitter.

The power requirements are 6.3 volts at 2.15 amperes and any plate voltage between 300 and 500 volts. At 300 volts the transmitter requires 115 milliamperes of plate power. If the car battery is up, this may easily be supplied by a single 100-milliampere, 300-volt vibrator supply. At 500 volts the transmitter requires 150-160 milliamperes. A *Carter Model 450AS* dynamotor will supply the correct operating voltage. A surplus PE-103A may also be used. A *Mallory VP-557* Vibrapack will also work well with this transmitter. At 300 volts, an input of 12 watts may be run. At 400 volts the input will be 20 watts, and the maximum input of 28 watts can be run with a 500-volt supply.

The Circuit

The r-f driver uses a 6J6 in a frequency quadrupling circuit using a 7-Mc crystal. The first half of the 6J6 is a modified Pierce oscillator, with the plate circuit tuned to 14 Mc. The second half of the 6J6 acts as a doubler to 28 Mc. It is essential that all r-f portions of this circuit (tube socket, coil forms, etc.) be made of low-loss ceramic or mica-filled bakelite. See *Fig. 5-5-A*.

The slug-tuned inductances resonate with the internal capacities of the tube and the residual circuit capacities to the correct frequencies. This relatively high L/C ratio allows broad band circuits yet still allows relatively high *Q* inductances. With 150 volts on the exciter and a plate current of 14 ma., this driver provides more than enough grid excitation for the 2E26 class C amplifier.

The 2E26 stage has a metering jack in the cathode circuit. This is a shorting type jack so the plate meter may be removed after tune-up. The same jack may be used for indicating either the 2E26 grid current or the total cathode current. When the switch *Sw1* is opened, the d.c. screen voltage is removed and the screen and plate currents are cut off, leaving only the grid current for the meter to read. Closing the switch restores the screen voltage and permits

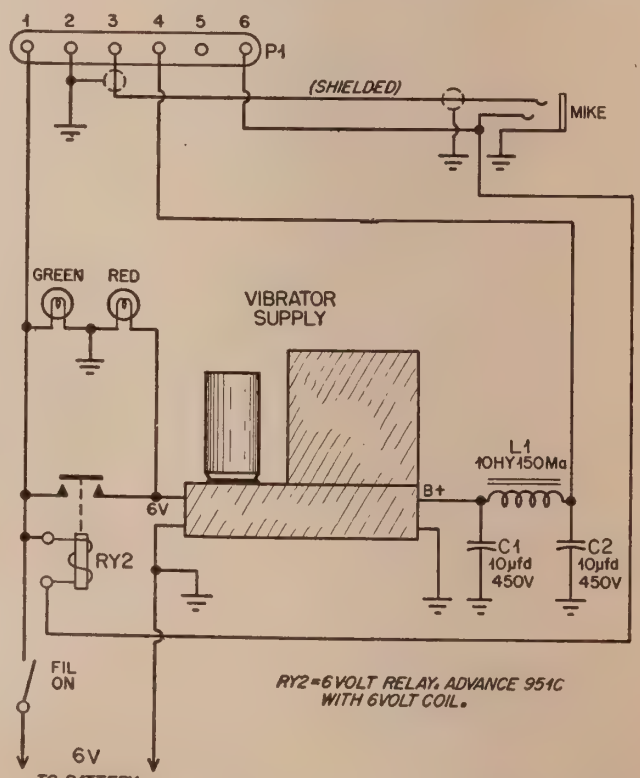
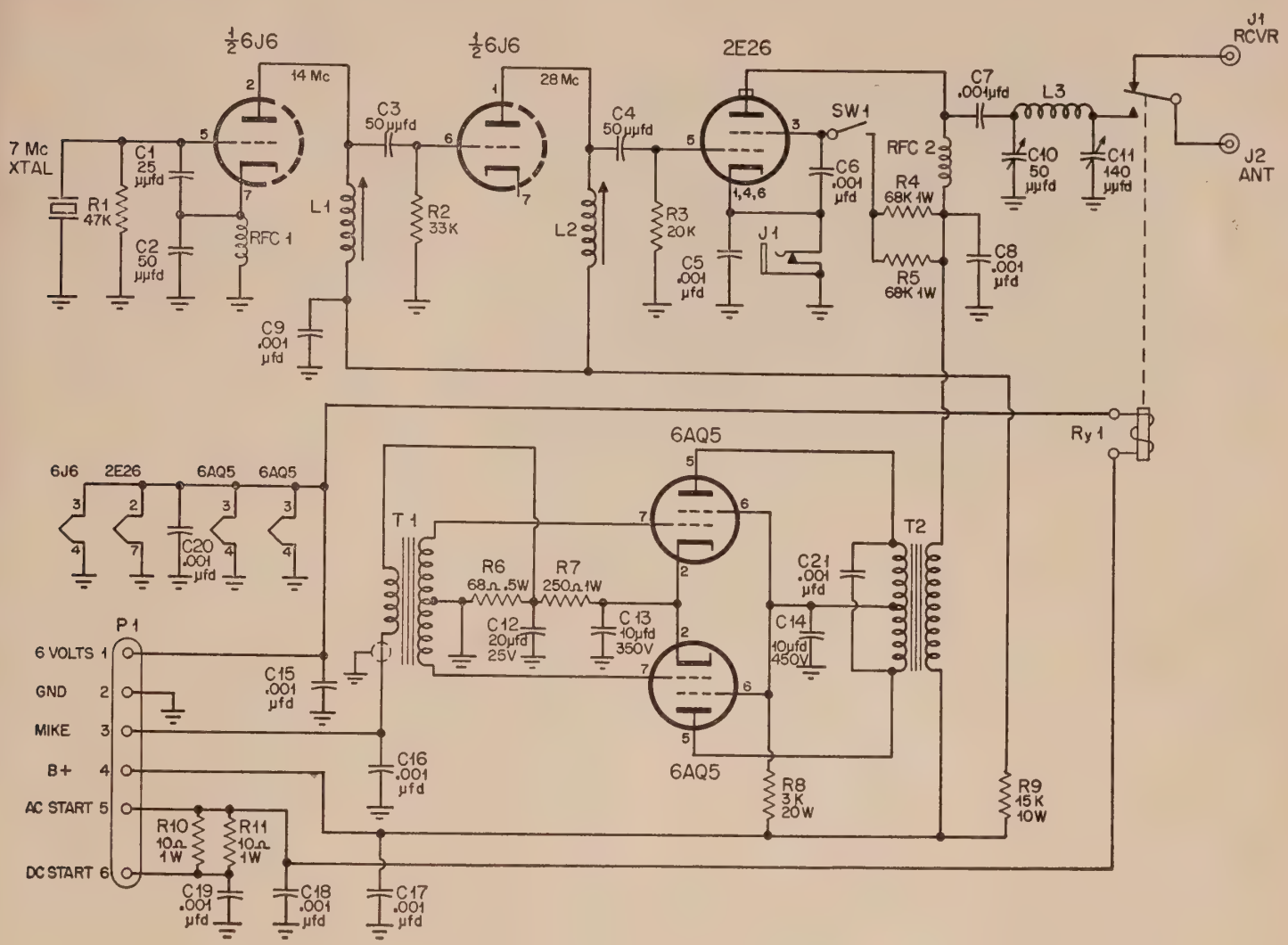


Fig. 5-5-B. Control wiring for the 28-28 phone transmitter.



C1—25 μμfd.
C2, C3, C4—50 μμfd.
C5, C6, C7, C8, C9, C15, C16, C17, C18, C19, C20, C21—0.001 μfd., Erie ceramicon 801-001.
C10—50 μμfd., variable.
C11—140 μμfd., variable.
C12, C13, C14—10 μfd., 450v.; 10 μfd., 350v; 20 μfd., 25v., Sprague TVL-3719.
J1, J2—Jack, ICA #2378.
L1—28 turns #24 XR-50 form. enam. National
L2—13 turns #18 enam. National XR-50 form.
L3—8 turns #18 enam., 1" long, ¾" dia., or B&W 3010.
P1—plug Jones 5308AB and socket P308CCT.
R1—47,00 ohms, 1/3w.
R2—33,000 ohms, 1/3w.
R3—20,000 ohms, 1/3w.
R4, R5—68,000 ohms, 1w.
R6—68 ohms, ½w.
R7—250 ohms, 1w.
R8—3000 ohms, 20w.
R9—15,000 ohms, 10w.
R10, R11—10 ohms, 1w.
RFC1—2.5 mh. choke.
RFC2—choke, Ohmite Z-28.
Ry1—relay, 6-volt a-c coil, d.p.d.t., Advance K1504.
T1—microphone transformer, 1:84 ratio, Peerless K-007X.
T2—Modulation transformer, 10,000-8,0000 ohms, Peerless M-013X.

Fig. 5-5-A. Wiring schematic and parts list of the 28-watt 10-meter transmitter.

plate and screen current to flow. Since the meter is really only needed during tune-up operations it is unnecessary to install it in the transmitter *(Fig. 5-5-D)*.

The output circuit of the 2E26 is a *pi*-network, designed to work into low impedance loads, such as are presented by the usual mobile whip antenna. It will also match low impedance lines, and random length antennas that might be used for portable work. Final amplifier loading is controlled by *C11*. In some installations it may be necessary to parallel *C11* with an additional fixed capacity of 100 μμfd. to reduce loading to the correct value.

The modulator is a pair of 6AQ5 tubes operating class AB1. This circuit will produce sufficient peak power to fully modulate a class C stage operating at 28 watts input. To make this possible, a microphone transformer with a turns ratio of 1:84 must be used. No additional speech amplification is then necessary. On voice peaks, the 6AQ5 tubes draw grid current which causes the driving voltage to drop. This causes a limiting action which effectively prevents overmodulation while, at the same time, allows a high average level of modulation.

The specified microphone transformer has a resonance at 1400 cycles which is the mid-frequency of the audio band necessary for effective transmission of speech. With the aid of *C8* across the output winding of the modulation transformer the modulator response is within the range of 350 to 3500 cycles, the frequencies of maximum effectivity for speech.

To eliminate the need for a mike battery, the microphone voltage is developed in the cathode circuit of the modulator. A *Western Electric*

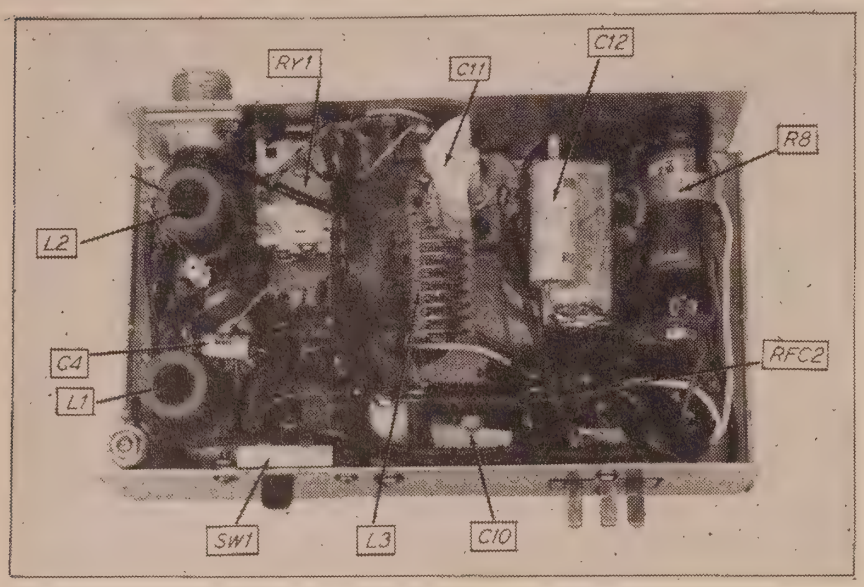


Fig. 5-5-C. Underchassis view of the 28-28 transmitter showing the placement of some of the major components.

F-1, or a surplus T-17B microphone will work well with this circuit.

The transmitter is controlled by relay, *Ry2,* which is operated by the microphone switch. This circuit may be used to operate another control relay to start a dynamotor, or it may be used to ground the center tap of a power transformer in an a.c. supply. Suggested control circuits are shown in *Fig. 5-5-B.*

The control relay, *Ry1,* is a standard 6.3-volt 60-cycle relay. It works well on about 3 volts d.c. In order to drop the voltage for d-c operation, *R10* and *R11* are wired in parallel and connected to plug *pin 6,* which is grounded by the mike push-to-talk switch. An external transmit switch must be used for a-c operation, as using the microphone control on an a-c circuit will introduce a.c. hum into the audio system.

Construction

The chassis box measures 2⅛" high, 3½" deep and 6" long and may be used. *Figure 5-5-C* is an *Bud AC-431* chassis measuring 2" high, 4" deep and 6" long and may be used. *Figure 5-5-C* is an underside view, showing placement of the small parts beneath the chassis. Looking at the top view for a moment: Across one end of the box are the crystal holder, *L2,* the 6J6 socket and *L1.* Between *L2* and the front edge of the box is the antenna coaxial receptacle. *R9* is mounted between *L1* and the corner of the chassis by a long bolt that passes through *R9* and mounts it "end-on" to the chassis. Be sure to put insulating washers on each end of *R9* to prevent the bolt from shorting the resistor to the chassis.

The 2E26 socket, *J1,* and the antenna relay are in a line parallel to *L1, L2* and the 6J6 socket. *C5* is mounted on *J2. Sw1* mounts on the side of the chassis directly above the 2E26 socket. *C6* is mounted on the 2E26 socket, connecting between *pins 3* and *4.* Condensers *C12, C13* and *C14* are combined in one triple unit, such as the *Sprague TVL-3719,* and mounts in a 1" diameter hole. The mounting plate should be used with this condenser, as it is next to impossible to solder the condenser to the aluminum chassis. This condenser mounts just about in the middle of the chassis. Condensers *C11* and *C10* are on each side of it, and coil *L3* is suspended below it. *L3* is self-supporting, mounted between the soldering lugs of *C11* and *C10.* A small ½-inch ceramic terminal is mounted to the rear lip of the box near *C10.* This terminal supports one end of *C7* and *RFC2.* The plate lead from the 2E26 comes through an insulated hole in the chassis and connects to the stator of *C10* and *RFC2.* Transformer *T2* is mounted above the chassis, its leads going through two insulated holes to the underneath side. The two 6AQ5 tube sockets are mounted at the extreme end of the chassis. *T1* is mounted below the chassis, one end being held by a mounting bolt of *T2.* In the original model shown in the photo, *C12* was not an integral part of the large filter can, being mounted atop *T2,* the ground end of *C12* being soldered to the frame of *C2.* Resistor *R8* mounts at the extreme end, beneath the 6AQ5 tube sockets. It, like *R9,* mounts "end-on" with a long machine bolt. The resistor has two fibre washers at each end for additional insulation.

Wiring

As many parts as possible should be mounted directly on the tube sockets to conserve space. *R1* is mounted across the crystal holder. *C1* is connected between *pins 5* and *7* of the 6J6. *C2* goes between *pins 7* and *4* of the 6J6. *Pin 4* is grounded to the socket bolt. *C3* connects between *pins 2* and *6* of the 6J6. *R2* goes from *pin 6* to *pin 4. C9* is connected between the "cold" lug of *L1* and the ground lug on the threaded shank of *L1. R3* mounts between *pins 5* and *7* of the 2E26. *Pin 7* is grounded. *C4* goes between the top (hot) end of *L2* and *pin 5* of the 2E26. *C8* goes directly from the "cold" end of *RFC2* to ground. The "cold" end of *RFC2* should be supported by an insulated terminal, *C8* going directly across this terminal. The remainder of the wiring is not critical as to placement. Condensers *C15, C16* and *C17* mount directly on the power plug and prevent r.f. from entering the cable leads.

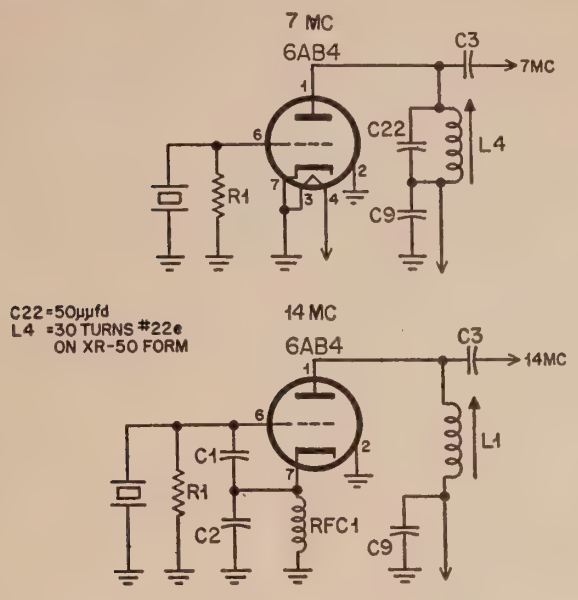


Fig. 5-5-E. Alternative 6AB4 oscillator circuit for 40-meter and 20-meter band operation.

Check Out

All wiring should be checked before applying filament voltage to the transmitter. When the tubes are lit, plug in a 7-Mc band crystal. Open *Sw1* to remove screen voltage from the 2E26. Plug a low range (0-15 ma.) milliameter in *J1*. The center arm of *J1* is "positive." Energizing the relay should indicate grid current of the 2E26 on the meter, if *L1* and *L2* are near resonance. If no grid current is observed, tune a receiver to the fundamental frequency of the crystal oscillator. If the crystal is oscillating, *L1* and *L2* are then adjusted for a grid current of 3-4 ma. on the 2E26. The meter in *J1* should be changed to a 0-100 ma. meter, and *Sw1* is closed, applying screen voltage to the 2E26. *C11* is set at full capacitance. Close the relay and resonate the final amplifier plate circuit with *C10*. Connect an antenna to the transmitter. Loading of the antenna is increased by decreasing capacity of *C11*. Re-dip the final after each change of *C11* by re-resonating *C10*. Continue adjusting *C11* and *C10* until the final is loaded as desired. Maximum loading will be at 70 ma. cathode current.

A field strength meter located several feet from the antenna is very useful in tuning the transmitter for maximum output.

The transmitter generates very little harmonic power. Only very mild interference on channel 2 is noticeable when the transmitter is near a television set of good design. An antenna filter would remove this last trace of interference if placed in the antenna feed line.

Adapting the Transmitter for Other Bands

This transmitter design can be easily modified for use on other bands. For the 21-Mc band, the second 6J6 would be tuned to 21 Mc. instead of 28 Mc. The output of the first section of the 6J6 providing enough 7-Mc energy to actively drive the second section as a tripler, even through *L1* is tuned to 14 Mc.

For 14 Mc., the second section of the 6J6 is not needed. A 6AB4 tube (equivalent to ½ of a 6J6) may be used in its place. For 7-Mc operation, a 6AB4 is used as a stranght crystal oscillator as in *Fig. 5-5-E*. For any other band than 28 Mc., a *National R-100* choke should be substituted for *RFC2,* which is only suitable for 28 Mc. All coils would have to be modified for the various bands.

5.6—The "28-9"

The "28-9" is another W6WYA transmitter, designed to work in conjunction with a 300-volt 100-ma. vibrator power supply. It is only 2" x 3½" x 6½" in size and small enough to mount easily under the dash of almost any car. The battery drain of this transmitter, under 100% modulation is less than 9.5 amperes—just about the drain of a good car radio. The circuit is shown in *Fig. 5-6-A*.

The r-f driver uses a 6J6 in a regenerative oscillator/doubler circuit that is very effective. The grid of the first half of the 6J6 will work either from a 7-Mc crystal or from 7 Mc. excitation from a VFO. The cathode r-f choke is a standard 2½ mh. 4 pie choke. Condensers *C1* and *C2* provide the r.f. feedback to the oscillator cathode necessary for oscillation. The plate cir-

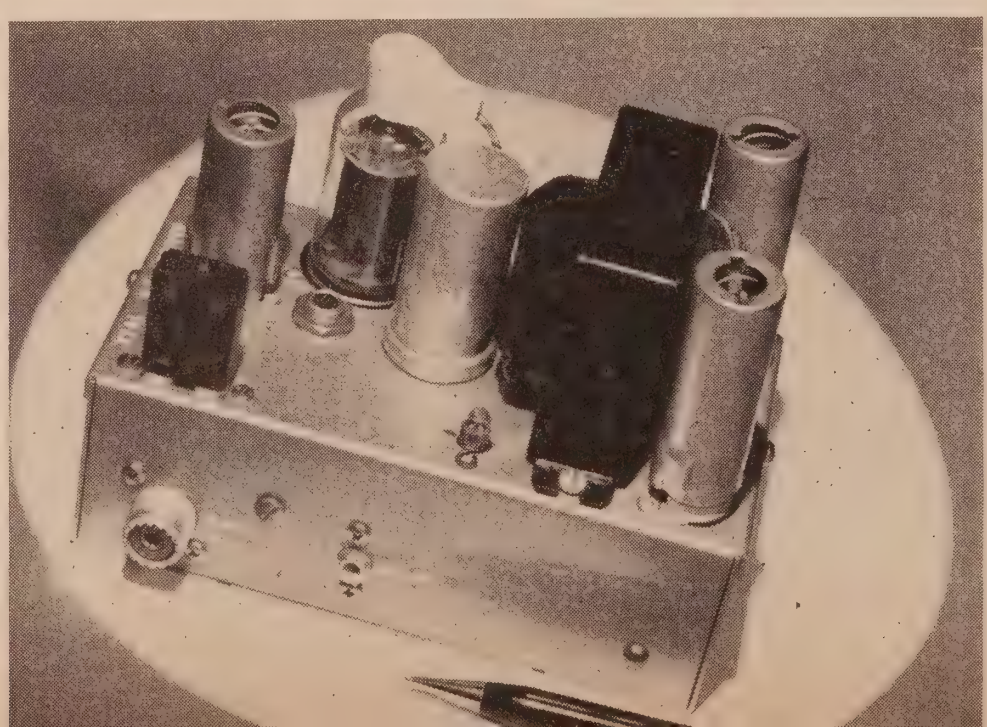
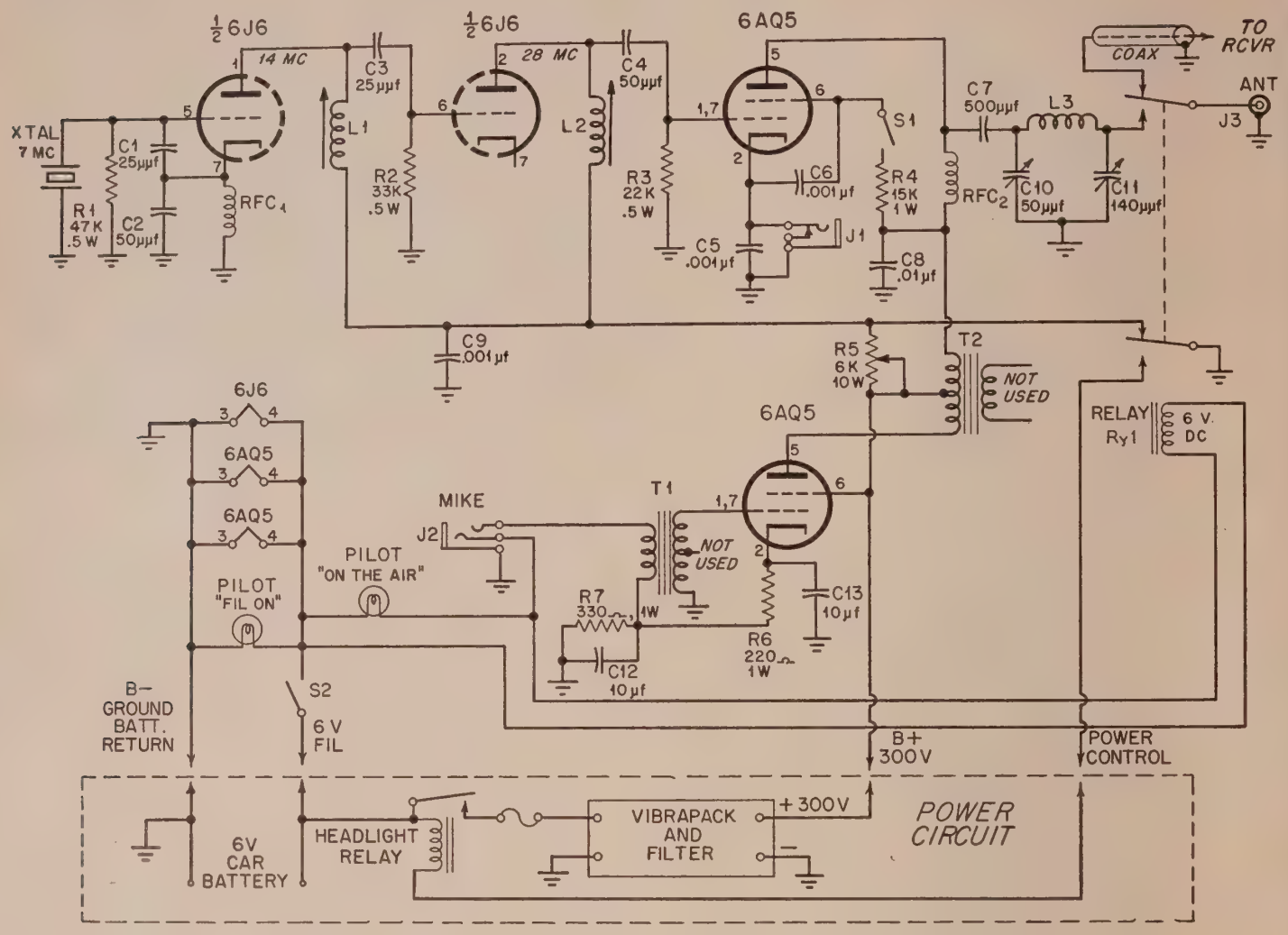


Fig. 5-5-D. The meter jack, J1 is located next to the 2E26 while C11 is mounted near the modulation transformer.



C1, C3—25 μμfd., ceramic.
C2, C4— 50 μμfd., ceramic.
C5, C6, C9—0.001 μfd., disc capacitor.
C7—500 μμfd., mica.
C8—0.01 μfd., disc.
C10—50 μμfd., midget variable.
C11—140 μμfd., midget variable.
C12, C13—10 μfd., 25v., electrolytic.
J1—closed circuit jack.
J2—3 circuit jack.
J3—"ANT" jack.
L1—28 turns # 24 enam. on XR-50 form.
L2—13 turns #18 enam. on XR-50 form.
L3—9 turns #18 enam., 1⅛" long, ¾" dia. from a B&W 3010.
R1—47,000 ohms, ½w.
R2—33,000 ohms, ½w.
R3—22,000 ohms, ½w.
R4—15,000 ohms, 1w.
R5—6,000-ohm adjustable, 10w.
R6—220 ohms, 1w.
R7—330 ohms, 1w.
RFC1—2.5 mh. r-f choke.
RFC2—Z28 Ohmite r-f choke.
Ry1—D.p.d.t. relay, 6v. coil.
S1, S2—S.p.s.t. toggle switches.
Chassis—2⅛x3½x6½
T1—Microphone transformer, 1:84 turns ratio (Triad A-5X).
T2—Replacement output transformer Chitran RO-304.

Fig. 5-6-A. Wiring schematic and parts list of the "28-9" mobile transmitter.

cuit of the oscillator is tuned to 14 Mc. by the self-resonating coil, *L1*. The second half of the 6J6 acts as a regenerative doubler to 28 Mc., regeneration being supplied by the common cathode impedance, *C2*. The plate circuit of the second half of the 6J6 is resonated by *L2* and the associated circuit capacities.

The class C stage uses a single 6AQ5 tube operating as a straight amplifier. An acceptable substitute for the 6AQ5 would be a loctal based 7C5. The 7C5 is equivalent in characteristics to, and is slightly more rugged than the 6AQ5.

The 6AQ5 is plate and screen modulated by a second 6AQ5. The output circuit of the r-f stage uses a 10-meter plate choke for maximum efficiency and minimum space. The output circuit is a *pi*-network, composed of C10, C11 and *L3*. The *pi*-network tank does a good job of helping the reduction of harmonics which cause TVI. It will match any antenna in the range of 30 to 500 ohms.

The Audio Circuit

The audio system uses a carbon mike to drive the mike transformer. This transformer is a gem worth all your efforts to obtain. It acts as an effective speech-frequency band pass filter, as its high impedance secondary is in parallel resonance at 1400 cps. (*The Triad Transformer Co.* and the *Peerless Division of Altec Lansing Co.*, both in Los Angeles, Cal., make this transformer.) The center tap on the secondary is not used. The entire secondary with its voltage step-up ratio of 1:84 is connected in the grid circuit of the 6AQ5 audio amplifier. To eliminate the usual mike battery some of the 6AQ5 cathode current is fed through the mike by

means of the resistor combination *R6* and *R7*. The mike voltage is 4½ volts with the mike switch closed.

In place of the usual modulation transformer an inexpensive replacement grade push-pull output transformer is used. In this circuit the output or speaker winding is ignored. Almost any such transformer may be used, but it is wise to select one designed for a 14,000-ohm plate-to-plate impedance, capable of carrying 50 ma. of d.c. and whose primary d.c. resistance is less than 300 ohms. Equally important is that it fit the rear of the chassis. Using a transformer designed for 14,000 ohms plate-to-plate the impedance each side of center tap will be sufficient at the low frequency end (300 cps.) for the 6AQ5 to develop full audio power. Since the audio and class C tubes are the same, the "modulation" transformer should have a 1:1 turns ratio, hence the use of ½ of the primary for the audio side and the other half to the class C modulated stage. A *Signal Corps* type 3—circuit mike jack with its smaller opening is used to prevent confusion with the metering jack and to fit the *T-17b* mike plug.

An additional feature of this audio circuit is its use as a public address system for emergency use or to direct the activities of an outdoor Hamfest. Switching the screen switch *S1* off, the class C stage is disabled unloading the modulator. Further, by switching a loud speaker to the previously unused 4-ohm secondary winding of the modulation transformer, 4.5 watts of audio are available for public address use.

The 0.01 μfd. disc ceramic capacitor *C8* in addition to being an r-f bypass capacitor also serves to attenuate the higher audio frequencies not required in speech communication. The over-all response of the modulator is within the range of 300 to 3500 cps.

Control Circuits

The control circuit uses a relay actuated by the standard push-to-talk switch in the carbon mike. Since the "28-9" was planned solely for mobile operation in the family car, a d-c relay is specified. The rig may be made to operate on a.c. or d.c. by merely replacing the d-c relay with a 6.3-volt a-c counterpart midget relay, connecting a 4-ohm 5-watt resistor in series. With the series resistor, the a-c relay operates equally well on either a.c. or d.c. The battery current drawn in this arrangement is greater than when using a 6-volt d-c relay.

One set of relay contacts switches the antenna from the receiver to the transmitter. The other set of contacts is used to start the power supply and short out the r-f driver plate voltage when the mike switch is released, permitting instantaneous break-in operation. Since the contact current in the midget relay is limited, it is necessary that another relay be used ahead of the vibrator power supply. For this purpose a conventional automobile single headlight relay with its built-in fuse is ideal. The fuse will protect the vibrapack in case of trouble.

Construction

The transmitter is built in a small "Minibox," such as the *Bud CU-2106* or the *L. M. Bender 138*. The box should measure at least 2⅛" x 3" x 5½". The *L. M. Bender* box is slightly larger than these dimensions. All parts are mounted on the main half of the box, as shown in *Fig. 5-6-B*. The 6J6 tube is mounted on the back apron to the extreme left. Next to it is the 6AQ5 r-f amplifier. The modulation transformer *T2* is next, and on the extreme right end of the apron is the 6AQ5 modulator.

On the front panel are, from left to right: The crystal holder with the green pilot (Fil.

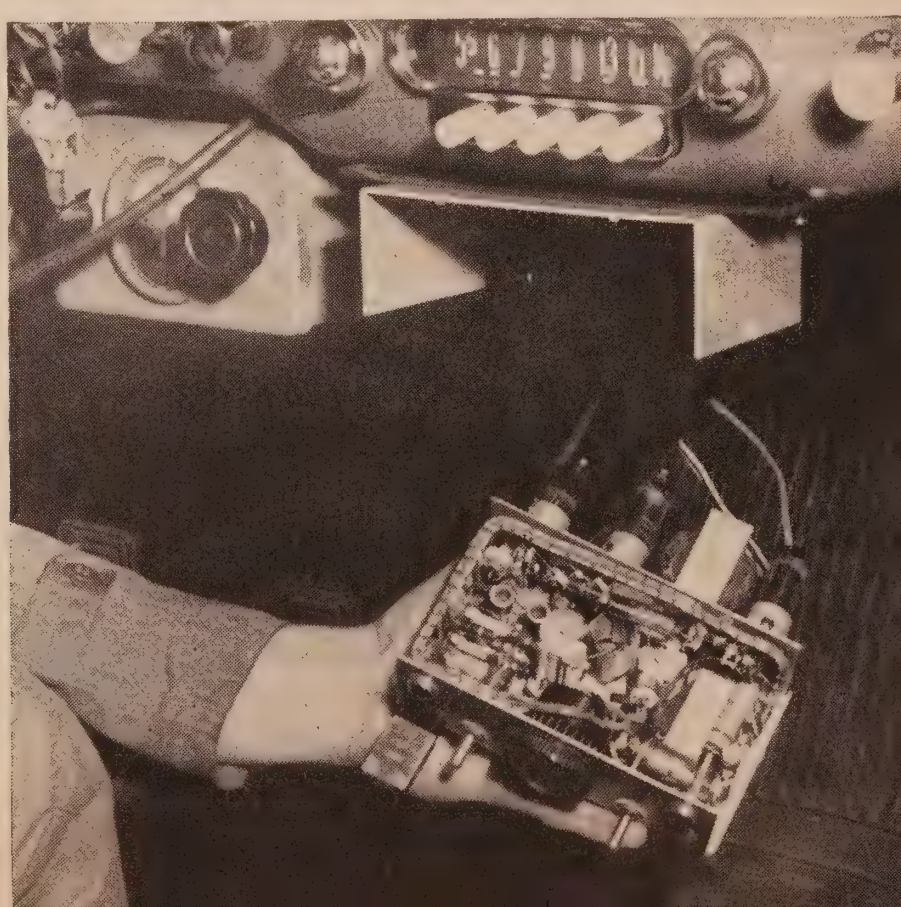


Fig. 5-6-B. This under the chassis view shows that the 28-9 may be made into an extremely compact unit. In this model (used by W6ZUM) a midget meter has been added in the power lead. The tubes project out the rear apron of the chassis.

On) above it, the filament switch, the plate meter (if one is used), the screen switch, *S1,* and finally the red pilot (On the air) and the mike jack.

The remaining parts are mounted on the deck of the chassis. Directly in front of the 6J6 socket are mounted *L1* and *L2*. Between these coils and the front panel is the antenna relay, *Ry1*. To the right of *L2* is *C10,* with its slotted shaft projecting out the bottom of the chassis. *C11* mounts almost directly in front of *T2,* with coil *L3* between *C11* and *C10*. *L3* mounts vertically, and is supported by its leads to *C10* and *C11*. At the right end of the chassis is *T1,* the microphone transformer. *R5,* the wire-wound resistor mounts on end by a long bolt between *T1* and the mike jack. Be sure to put insulating washers on both ends of *R5* to prevent it from shorting to the chassis or mounting bolt. Since chassis space is at a minimum no cable receptacle and plug are used. The power leads come out the back of the chassis through a rubber grommet and are laced with twine to form a cable. A female plug is placed at the end of the cable.

Wiring

It is necessary to use a light grade of plastic insulated wire to prevent the wiring from becoming cumbersome. *Belden 8901* plastic insulated wire will do the job well.

Resistor *R1* should mount across the crystal socket. Mount *C1* between *pins 5* and *7* of the 6J6 socket. Ground *pin 3*. Wire *C2* between *pins 7 and 3*. Wire *R2* between *pins 6* and *3*. *C3* connects between *pins 1* and *6*. *C9* connects to the "cold" end of *L2* and the mounting lug of *L2*. *C4* mounts between the 6J6 socket and the 6AQ5 socket. *R2* connects between *pins 1* and *3* of the 6AQ5 socket, *pin 3* being grounded. *C6* mounts directly between *pins 2* and *6* of the 6AQ5, while *C5* connects between *pins 2* and *3*.

The audio components fit into the space between the 6AQ5 modulator and *T1*.

Tuning Procedure

The coil of relay *Ry1* should be temporarily disconnected and the relay contacts held closed with a matchstick. Apply 6.3 volts a.c. to the filaments of the transmitter. With the screen switch *S1* opened, a meter plugged into *J1* will read the grid current to the 6AQ5 tube. Using a 7-Mc crystal, *L1* and *L2* are adjusted for a grid current reading of 3-4 ma. Resistor *R5* may be adjusted to a lower value to increase the output of the 6J6, if necessary. When switch *S1* is closed, the meter will read the total cathode current. With *C11* set at maximum capacity, *C10* is adjusted for a dip in cathode current, indicating resonance. A suitable antenna load should be connected to *J3* and *C11* decreased in capacity until the 6AQ5 cathode current is in the region of 50 ma. *C10* should be resonated each time a change is made in the capacity of *C11*.

In some cases, depending upon the SWR of the antenna system, and additional fixed capacity of 100 $\mu\mu$fd., placed in shunt with *C11* may be necessary to reduce loading to 50 ma. cathode current.

The transmitter should be disconnected from the a.c. operated supply, and the lead to *Ry1* reconnected. The transmitter is now ready for installation in the car.

Antenna Connections

The "28-9" works best with a quarter-wave whip antenna. Since this antenna has a load resistance of only 36 ohms, an impedance matching section is recommended to raise the impedance up to 72 ohms. The matching section consists of a quarter-wave electrical wave length section (67 inches for 10 meters) of 52-ohm coax line with one end connected to the antenna and the other end connected to a 72-ohm coax line of sufficient length to reach the transmitter. Its use affords a better match to the *pi*-network. Also, if the XYL objects to the conspicuous quarter-wave whip, the automobile's regular BC antenna does a good job as the transmitting antenna. A *Motorola* type antenna plug and jack are used as the antenna connection. A short length of coax line brought out through the chassis connects the antenna to the receiving converter.

5.7—12-Watt Mobile 3-Band Transmitter

This transmitter is designed to operate from a 300-volt, 100-milliampere supply, such as a *Vibrapack* or a small dynamotor, such as the *Carter MA-301*. It is small in size and is designed to bolt directly to the firewall of the car. The final amplifier runs 12 watts input, and delivers an output of 8 watts of fully modulated carrier on 40, 80 and 160 meters.

The outside view of the transmitter is shown in *Fig. 5-7-A,* and the complete wiring schematic is shown in *Fig. 5-7-B*. A 6C4 functions as a Pierce oscillator, using crystals on 40, 80 and 160 meters for output on these bands. The oscillator is capacity coupled to a 5763 miniature beam pentode tube, running at 300 volts and 40 ma. plate input. The 5763 operates as a straight amplifier at all times, thus minimizing harmonics and the danger of TVI.

The 5763 is plate and screen modulated by a single 12AX7 class B triode modulator. The modulator stage is driven by a 12AU7 connected as a two-stage audio amplifier. A high output carbon microphone is inserted in the cathode circuit of the 12AU7, obtaining the button voltage from the cathode current of the 12AU7 tube. The first half of the 12AU7 is a grounded grid class A amplifier, capacity coupled to the second half of the 12AU7 operating as a voltage amplifier.

The plate tuning control for the 5763 stage is the only control on the transmitter. It is merely necessary to insert the correct crystal and proper plate coil, and tune the output tank to resonance. The transmitter is then in operation.

Mechanical Layout

The complete transmitter is built in a *Bud box shield, BS-1244,* measuring 4½x5x7½ inches in size. This box had two flanges that run along its rear edges and make it possible to bolt the box to the firewall of the car with a minimum of trouble.

A sub-chassis measuring 7⅜" x 4⅜" is cut from a sheet of 24ST aluminum and mounts vertically along the length of the box, running approximately along the mid-section of the box. The tubes are mounted on this plate, along with the other major components of the transmitter. The only components that are mounted directly to the box are the microphone plug, the crystal holder, the coaxial output plug and the power plug. These may all be seen in *Fig. 5-7-A.*

The plug-in coil for the 5763 mounts on the sub-chassis and may be withdrawn through a 1½" hole punched in the lower right corner of the box. A rod and handle is attached to each coil as shown in *Fig. 5-7-C* to permit easy withdrawal and insertion of the coils. The plate tank, condenser for the 5763 *(C6)* mounts on the sub-chassis, and the shaft is brought through the front panel by a flexible coupling and a short length of ¼" brass extension rod.

The dimensions of the sub-chassis are shown in *Fig. 5-7-D.* Two strips of ¼"x¼" bar aluminum, each 4⅜" long run along the short edges of the chassis. These bars are tapped for 6-32 screws, which fasten the bars to the sub-chassis. These bars, in turn, are tapped on the opposite sides for 6-32 screws, which hold the chassis in place in the box.

All holes on the sub-chassis should be drilled, and the sockets and transformers temporarily mounted in place. The 5763 tube should be put in the socket, and a tube shield placed over the 5763. The chassis should then be slid into the box for correct placement and drilling of the box holes to match the 6-32 tapped holes in the square bar stock.

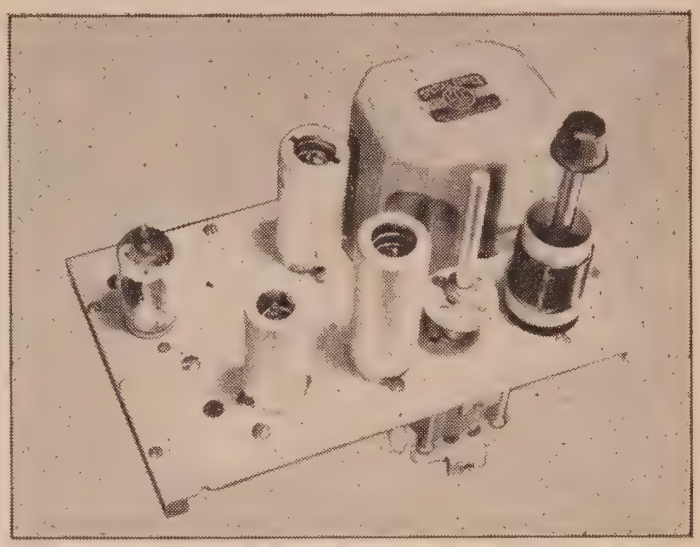


Fig. 5-7-C. Top view of the chassis. The hole for the microphone wires is visible next to the unshielded 12AU7. The hole for the crystal leads is next to the 6C4 oscillator tube. The p-a coil is at the lower right hand.

Fig. 5-7-A. This miniature 12-watt transmitter operates from a 300-volt, 100-milliampere power supply. It is designed to be mounted directly to the firewall of the automobile in the same manner as the car heater. It operates on the 40, 80 and 160-meter bands.

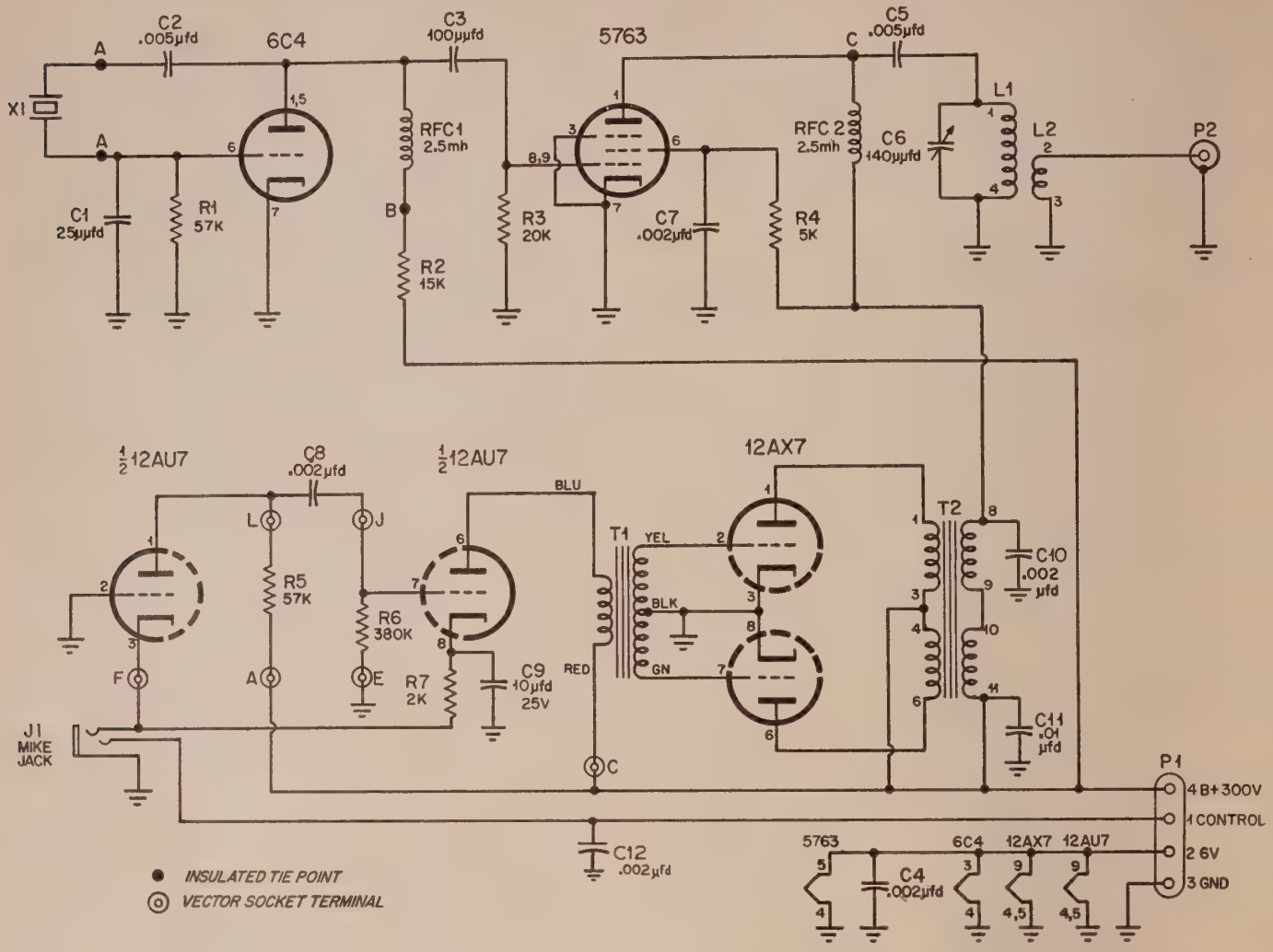


Fig. 5-7-B. Wiring schematic and parts list of the 12-watt transmitter featuring plug-in coils.

C1—25 μμfd., Erie GP1K-250 or Centralab D6-250.
C2, C5—0.005 μfd., Erie 811-005, or Centralab MD-502.
C3—100 μfd., Erie GP1K-101 or Centralab D6-101.
C4, C7, C8, C9, C10, C12—0.002 μfd., Erie 811-002 or Centralab MD-202.
C6—140 μμfd., variable, Bud #MC-1856.
C9—10 μfd., 25-volt, Sprague TVA-1204.
C11—0.01 μfd., Erie 821-01 or Centralab MD-103.
J1—3-circuit microphone jack, ICA 1922.
P1—socket P-304-RP, Cinch-Jones and plug, S-304-CCT.
P2—antenna jack, ICA #2385.
R1, R5—57,000 ohms, 1/3w.
R2—15,000 ohms, 1w.
R3—20,000 ohms, 1w.
R4—5000 ohms, 1w.
R6—380,000 ohms, 1/3w.
R7—2000 ohms, 1/3w.
RFC1—2.5 mh. choke, J. W. Miller #4666.
RFC2—2.5 mh. choke, National R-100.
T1—Driver transformer, Merit A-2920.
T2—20-watt modulation transformer, UTC S-18.
X1—FT-243 crystal holder, Millen 33302.

It will be seen at once that there is only a little clearance between the 5763 tube shield and the front of the box. The critical dimension is from the top of the 5763 shield to the back of the condenser shaft of the p-a plate tuning condenser, *C6*. This over-all dimension is about 4¾". The inside depth of the box is about 4 15/16", so there is a little less than ⅛" clearance between the 5763 shield and the panel, and between the rotor shaft of *C6* and the back of the box.

The panel bushing hole for *C6* is cut slightly oversize to allow some tolerance in the alignment of the extension shaft. It is necessary to use a two bearing condenser for *C6* such as specified, since there may be considerable lateral force on the shaft when the sub-chassis is placed in the box. A single bearing condenser was first used, but the shaft was quickly forced out of alignment when the weight of the sub-chassis was accidentally supported by the condenser shaft during installation.

Wiring the Sub-Chassis

The tube sockets, transformers, *C6* and tie-points *A-A'*, *B* and *C* should be mounted on the sub-chassis (See *Fig. 5-7-E*). The socket for

Coil Table

160 Meters

L1—55 turns, #26 enam., 1" dia., 1" long.
L2—8 turns of insulated wire, wound over the ground end of L1.

80 Meters

L1—29 turns, #20 enam., 1" dia., 1" long.
L2—5 turns of insulated wire, wound over the ground end of L1.

40 Meters

L1—17 turns, #18 enam., 1" dia., 1" long.
L2—4 turns of insulated wire (hookup type) wound over the ground end of L1.

the 12AU7 is a *Vector 8N-9T Turret Socket*. It should be wired before it is installed. The lug terminals of the *Vector* socket are lettered, and it should be wired in this fashion:

1. *Pins 2, 4* and *5* of the socket are grounded to a socket lug.
2. A 57,000-ohm ½-watt resistor (*R5*) is connected between *pin 1* and *lug A*.
3. A 0.38-megohm ½-watt resistor (*R6*) is connected between *pin 7* and *lug E*.
4. A 2000-ohm ½-watt resistor (*R7*) is connected between *pin 8* and *lug F*.
5. A .002 μfd. condenser (*C8*) is connected between *lug L* and *lug J*. *Lug L* is connected to *pin 1*, and *lug J* is connected to *pin 7*.
6. *Pin 3* is connected by a wire to *lug F*.
7. *Lug E* is grounded to a socket ground lug by a short piece of wire.

This completes the preliminary wiring of the 12AU7 socket and it may be mounted on the sub-chassis.

Audio Wiring

The various connections to the 12AU7 socket may now be made. The red lead of *T1* connects to *lug C* of the *Vector* socket. *Lug A* is jumpered to *lug C* and *R2* connects between *lug C* and a terminal post (*B*) mounted in a small hole between the *Vector* socket and the 6C4 socket. The blue lead of *T1* connects to *pin 6* of the *Vector* socket. A filament lead runs from *pin 9* of the *Vector* socket to *pin 3* of the 6C4 socket.

R.F. Wiring

Start with the crystal oscillator. Ground *pins 4* and *7* of the 6C4 socket. Connect *RFC1* between the tie-point *B* and *pin 1*. Connect *C2* between *pin 5* and tie-point *A*. Connect *R1-C1* between *pin 6* and the ground lug under the socket bolt. Connect *pin 6* to tie-point *A'*. Connect *R3* between *pin 9* of 5763 socket and the ground lug under 6C4 socket bolt. Connect *C3* between *pin 1* of 6C4 socket and *pin 8* of 5763 socket. Jumper *pins 8* and *9* of 5763 socket. Ground *pins 3* and *4* of 5763 socket. Connect *C4* between *pins 4* and *5*. Connect *C7* between *pin 6* of 5763 socket and ground lug of 6C4 socket. Connect *R4* between *pin 6* of the 5763 and *lug 8* of *T2*. Connect *pin 5* of 5763 socket to *pin 3* of 6C4 socket and also to *pin 9* of 12AX7 socket. Connect *C5* between *pin 1* of 5763 socket and stator of *C6*. Attach tie-point *C* to socket bolt of 5763 socket next to *pin 5*. Jumper tie-point *C* to *pin 1*. Connect *RFC2* between tie-point *C* and *lug 8* of *T2*. Connect *C9* between *lug 8* of *T2* and socket bolt of 12AX7 modulator. Connect stator of *C6* to *pin 1* of coil socket. Ground *pins 3* and *4* of coil socket to a lug under a socket bolt. Connect *C10* between *lug 8* of *T2* and a ground pin of coil socket. This completes the preliminary r.f. wiring.

The P-A Plate Coil

The only tuned circuit in the transmitter is the p-a plate tank circuit, *L1-C6*. The coil, *L1*, is wound on a *National XR-1* 4-prong, 1-inch diameter coil form. This coil may be inserted in the coil socket of the p-a stage through the 1½" hole in the lower right-hand corner of the panel. To facilitate the insertion and withdrawal of the coil a simple extension handle may be made up for each coil out of a 3¼" length of ¼" extension-shaft rod. This rod is tapped for a *6-32* flat head screw at one end, and fastened to the middle of the coil base by a *6-32* flat head screw. A standard ½" knob is placed on the other end of the shaft. The base of the coil may be countersunk to accept the flat head screw. This makes a firm and strong handle to allow the operator to change coils quickly and easily. A drawing of the handle assembly is shown in *Fig. 5-7-D*.

The 12AX7 socket should now be wired Ground *pins 3, 4, 5* and *8*. Connect the yellow and green leads of *T1* to *pins 2* and *7* of the 12AX7 socket. Ground the black lead to *pin 4*. Connect *pins 1* and *6* to *taps 1* and *6* of *T2*. Jumper *taps 3* and *4* of *T2* and connect the jumper to *tap 11*. Jumper *taps 9* and *10*. Connect *lug A* of *Vector* socket to *lug 4* of *T2*.

Connect *C9* between *pin 8* of the 12AU7

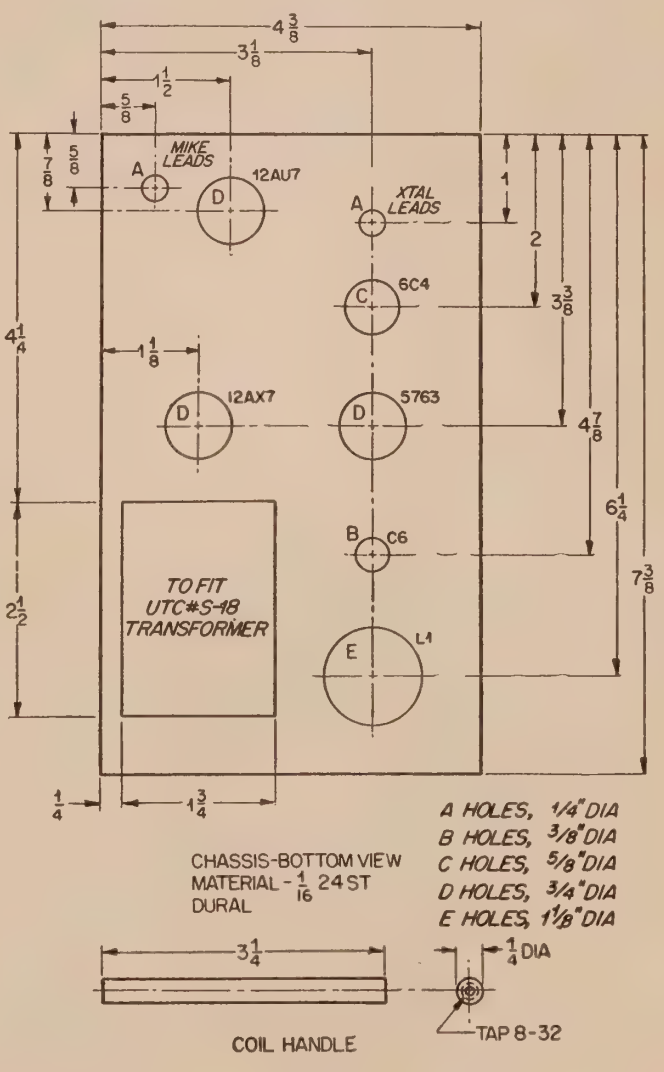


Fig. 5-7-D. Sub-chassis dimensions and coil handle construction.

socket and the bolt holding one side of *T1*. This completes the preliminary audio wiring.

Testing and Checkout

Before the sub-chassis is finally put in the box, a preliminary checkout of the circuit wiring should be made. The following temporary connections to the transmitter should be made:

1. Solder the crystal holder between tie-*points A* and *A'*.
2. Connect a ground return lead to *pin 3* of coil socket.
3. Connect a filament lead to *pin 9* of 12AX7 socket.
4. Connect a B plus lead to *lug 4* of *T2*.
5. An a-c supply capable of delivering 300 volts at 100 milliamperes (see *Chapter 7.3)* should be connected to the transmitter as shown in Fig. *5-7-F*. A 0-100 ma. meter should be connected in the B plus lead as shown.
6. A dummy load should be made of four 100-ohm 2-watt composition resistors connected in parallel, as shown in *Fig 5-17-F*.
7. This 25-ohm 8-watt dummy load should be connected to *pins 2* and *3* of the coil socket by two short lengths of hook-up wire. If a 0-1 ampere thermocouple r-f ammeter is handy, it should be placed in series with the dummy load.
8. A crystal should be plugged in the crystal holder, and a 6C4 tube placed in the oscillator socket. The filament supply and B plus should be turned on. When the 6C4 has warmed up, the oscillator plate current should be about 8 ma., as measured on the meter in the common B plus lead. When the crystal is pulled out of the crystal socket, the 6C4 plate current should increase to about 10 ma.

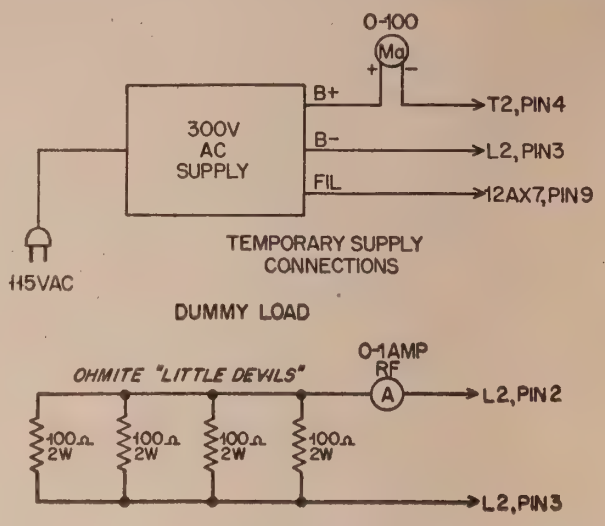


Fig. 5-7-F. Temporary power supply connections and wiring of the dummy load.

9. The power should be turned off, and the 5763 tube plugged in the p-a socket. The supply should be turned on, and when the 5763 tube has warmed up, the p-a tuning condenser should be tuned for a resonance dip in plate current as indicated on the 0-100 ma. meter. The total off-resonance plate current should be about 65 ma., and the resonance plate current about 55 ma. The resonance plate current will depend largely upon the closeness of the coupling between coils *L1* and *L2*. The proper coupling may be set later. The important objective now is to find the point of resonance of the tank circuit, and to check out the transmitter. Remember that the meter is reading the *sum current* of the 6C4 plate current and the 5763 plate and screen current. It will also read the currents of the other tubes as they are plugged in.

(Continued on page 117)

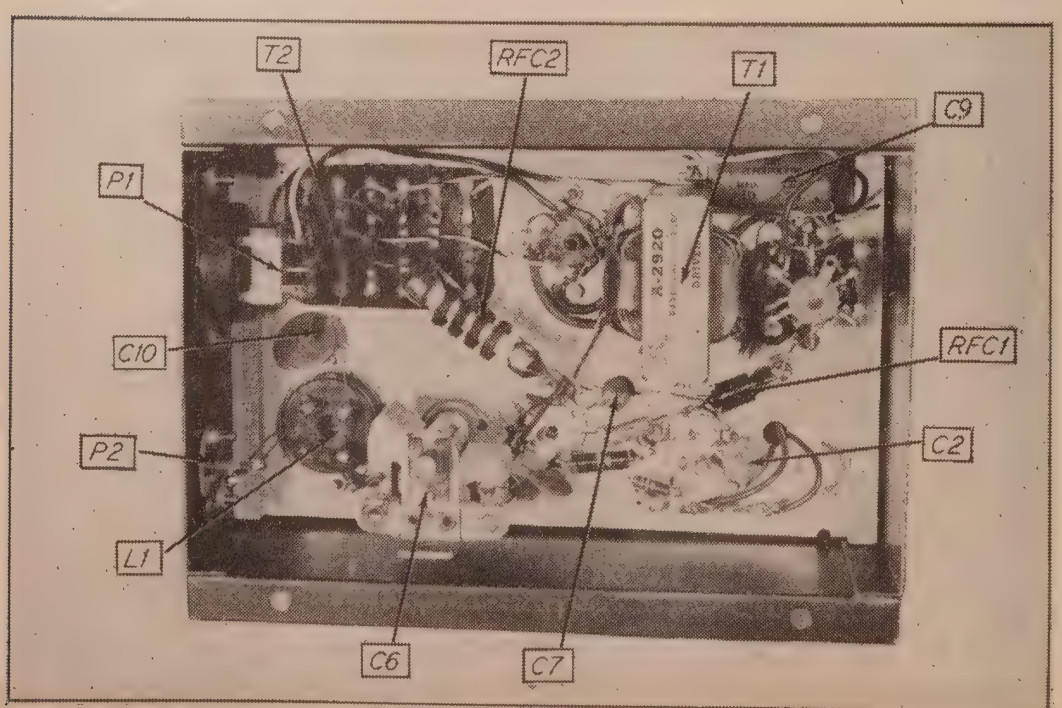


Fig. 5-7-E. Bottom view of the chassis showing the placement of parts.

Chapter Six

Mobile Antennas

6.1—Mobile Antennas

The success or failure of mobile operation depends upon the efficiency of the antenna installation. A 10-watt mobile transmitter working into an efficient and well designed mobile antenna will out perform a 100-watt mobile transmitter using a poorly designed antenna of low efficiency. The mobile amateur must compete with high powered fixed stations, many of them using beam antennas. The mobile Ham is thus at a distinct disadvantage. He is running low power, and he is using an antenna that often does not make the best use of his limited power.

It is the purpose of this chapter to discuss mobile antennas in general, and to illustrate some specific examples of high efficiency mobile antennas that will allow the mobile Ham to compete with fixed stations in the most efficient manner.

In the great majority of mobile installations, some kind of vertical whip is used as both the transmitting and receiving antenna. The vertical antenna has been in use for both long and short wave transmitting since 1924. It is used at v.h.f. for navigational aids and general communication. It is used at low frequencies for radio ranges and general broadcasting. During the past ten or fifteen years, the radio amateur has pioneered the use of the loaded vertical antenna for mobile transmission and reception. This is one stage of the art that is exclusively an amateur development and like other such amateur developments, has now spread to the commercial fields.

The Vertical Antenna

To understand the operation of a mobile antenna, it is perhaps wise to start the investigation with a very simple case: An eight-foot vertical copper rod with its lower end mounted an inch or so above an infinite area copper ground sheet *(Fig. 6-1-A)*. If this antenna is connected to the ground sheet through a single-turn loop of wire, and a grid dip oscillator is coupled to the loop, the resonant frequency of the antenna may be measured. The first quarter wave resonance will occur at about 29.5 Mc. The current distribution in this antenna is shown by the dotted line, and an equal current is flowing in the ground sheet as indicated, dropping to a very low value as the distance from the vertical antenna gradually enlarges.

By the use of other instruments, we are able to measure two other properties of this simple antenna: the *radiation resistance* and the *reactance*.

The term *radiation resistance* is very important. Briefly, it means that value of resistance which, when substituted at a current loop in the antenna system for the antenna, would dissipate the same amount of energy in the form of heat as the antenna radiates into space. The value of radiation resistance varies from one antenna to another, and varies with the relation of the antenna to surrounding objects, such as trees, buildings, etc.

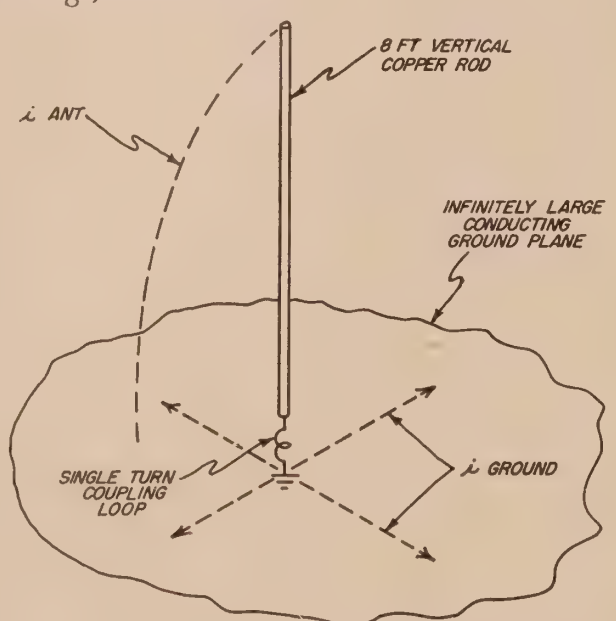


Fig. 6-1-A. A simple vertical antenna mounted above an infinitely large ground plane. The antenna current (i_{ant}) increases sinuosoidally towards the base of the antenna. The ground currents (i_{ground}) are equal in summation to the antenna current.

In order to efficiently transfer the power from the transmitter to the antenna it is necessary to match the transmitter feed system to the radiation resistance of the antenna. For normal values of radiation resistance, this may be done simply and efficiently. For very low values of radiation resistance, such as might be encountered in some mobile antennas, it is a difficult task and *most of the transmitter power output is lost in the matching system.* This is the danger that we must be aware of in mobile work, and which requires us to put much time and effort into the design of the mobile antenna and feed system.

Keeping these ideas of radiation resistance in mind, we can make a series of measurements on and about the resonant frequency of this simple vertical antenna. At any one given frequency this antenna will present a certain value of radiation resistance, *r*, and a certain negative or positive amount of reactance, *x*. The term *reactance* indicates an opposition to the normal flow of current, and must be cancelled out or otherwise neutralized in order to allow an efficient transfer of energy from the transmitter to the antenna.

If the various values of *r* and *x* that have been measured on the eight-foot vertical antenna are plotted, a curve similar to *Fig. 6-1-B* will result.

At the resonant frequency of 29.5 Mc. the matching conditions are almost ideal. The antenna presents to the loading system a radiation resistance of 32 ohms, with no reactance. (The definition of resonance infers that the total reactance of the antenna circuit referred to the feed point is zero.) A load of 32 ohms may easily be matched to the average transmitter using a coaxial cable, with a *pi*-network, or a pick-up link. The *Q* of the antenna is relatively low, and the antenna will accept power over quite a wide frequency range without having to resort to complicated tuning networks. The efficiency of the antenna is very high, as the loss resistances are of the order of fractions of an ohm.

FREQUENCY (Mcs)	RADIATION RESISTANCE (OHMS)	REACTANCE (OHMS)
29.5	32	0
21.0	11	−250
14.0	3.5	−600
7.0	1.0	−1200
4.0	0.2	−1600

Table 6-1-A. Summary of the characteristics of the antenna graphically illustrated in Fig.

This same eight-foot rod, operating at a frequency of 21 Mc. has quite different characteristics than when it operated at 29.5 Mc. Referring to the curves of *Fig. 6-1-B* it can be seen that the radiation resistance has dropped to a value of 11 ohms, and that a negative reactance of -250 ohms has appeared. At 14 Mc., the radiation resistance of the rod has dropped to 3.5 ohms, and the reactance has risen to −600 ohms. At 7 Mc., the radiation resistance has decreased to 1 ohm, and the reactance has increased to -1200 ohms. At 4 Mc., the radiation resistance of the rod has dropped to the low value of 0.2 ohms, and the reactance has climbed sharply to -1600 ohms. These characteristic figures for the eight-foot rod are summarized in *Table 6-1-A*.

Table 6-1-A tells us what we wish to know about this particular antenna. It tells us the radiation resistance of the antenna at each frequency we are interested in, and therefore tells us the load that the transmitter must be capable of matching. The chart also tells us the values of negative reactance at each frequency, and by the definition of resonance mentioned above, we know that we must cancel out or neutralize these exact values of reactance at each specified frequency. In other words, we must *resonate* the

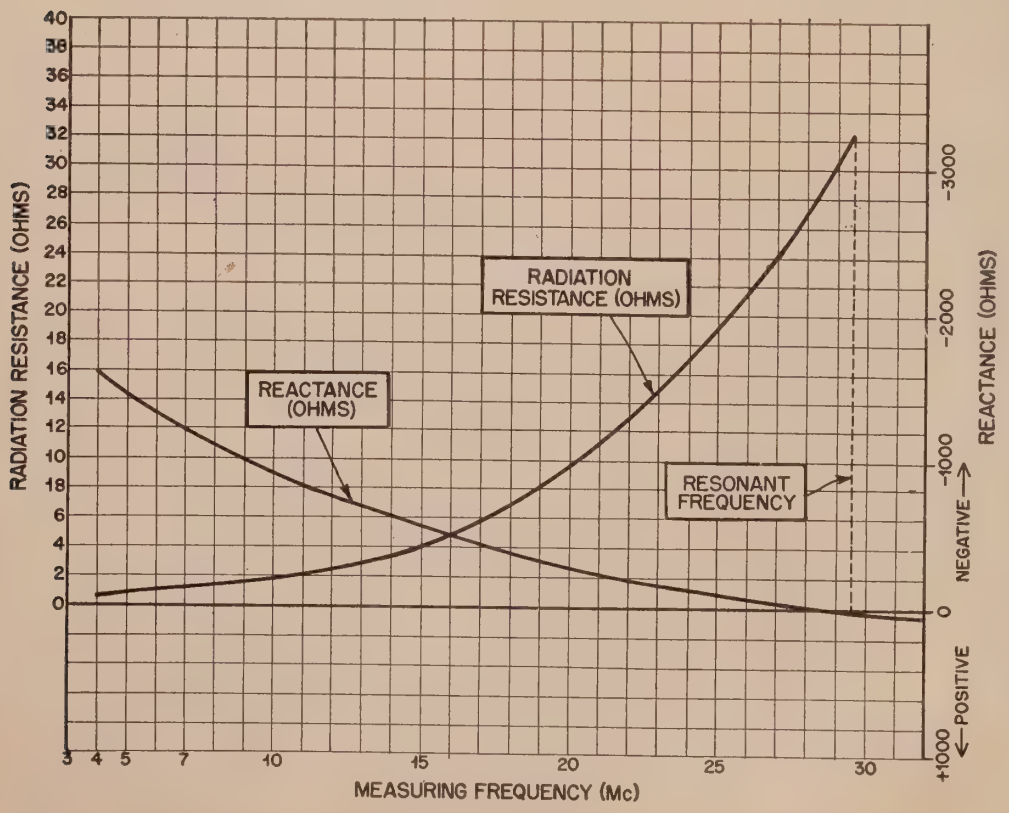


Fig. 6-1-B. Typical measurements made on an eight-foot vertical whip antenna suspended over an infinite ground plane. The antenna is resonant at 29.5 Mc.

ntenna to the desired frequency by adding *positive* reactance to the antenna circuit.

Resonating the Short Vertical Antenna

A short vertical antenna may be "tuned" to a requency considerably lower than its natural requency by the addition of a suitable induc-ance of the correct positive reactance that will esonate the antenna to the desired frequency. uch an inductance is termed a *loading coil.* The loading coil may be placed at any point in he antenna circuit *(Fig. 6-1-C).* Resonance may e obtained with the coil at any of the locations hown, but the efficiency of the over-all antenna ystem and the ease of matching of the system nay vary greatly with the placement of the oading coil. The examples in *Fig. 6-1-C* assume n operating frequency of 4.0 Mc.

In *"A,"* the loading coil is mounted at the ase of the whip, in a shielded box to prevent adiation from the coil, or any form of inter-ction between the coil and the whip. Assume he box is of such dimensions that it does not letract from the *Q* of the coil. At resonance, his antenna system would exhibit no reactance, nd a radiation resistance very close to 0.2 ohms.

In *"B,"* the vertical antenna is again base oaded by a coil, *L.* The coil is mounted with ts axis coincident with the axis of the whip. The coil is unshielded and free to radiate. The mount of radiation from this coil is dependent pon the shape and size of the coil. The act of adiation from the coil *raises* the radiation re-istance of the antenna system from the very ow value of 0.2 ohm to some higher value in he vicinity of 2 ohms. This new value depends argely upon the configuration of the coil.

In *"C,"* the loading coil is mounted half way p the vertical rod. The coil and the section of he rod beneath the coil have considerable cur-ent flowing in them during actual operation, nd the antenna radiation resistance is raised o the vicinity of 4 ohms.

In *"D,"* the loading coil is placed at the top of the antenna, with a capacity "hat" above it to provide capacity to ground. The radiation resistance in this case has risen to about 6 ohms.

From these examples it can be seen that the placement of the loading coil has a direct effect upon the radiation resistance of the short antenna. Since, in general, the higher the radiation resistance of the antenna system, the greater the over-all efficiency of the system, it would follow that some form of top or center loading would be best for mobile operation and that base loading in any form is to be avoided, if possible.

Placement of the Loading Coil

Figure 6-1-D shows the four examples of *Fig. 6-1-C,* with the addition of the curves illustrating the current distribution of each antenna.

The radiated field surrounding an antenna, other things being equal, is proportional to the current flowing in the antenna, and to the length of the antenna carrying this current. The short vertical rod radiating the best signal, therefore, will be the one that has the most current flowing in it per unit of length. In *"A,"* of *Fig. 6-1-D,* the whip impedance is very high, and the current flowing in it is very low The buildup of current occurs in the loading coil. Since this coil is shielded, this coil current cannot aid in any way to the radiation of the antenna. In *"B,"* the same coil is unshielded, and the current flowing through it is partially radiated. This act of radiation raises the radiation resistance of the whole antenna system a certain amount. In *"C,"* a high current flows in the section of the antenna beneath the loading coil, so the bottom section of the antenna contributes materially to the total radiation from the antenna system. In the ideal case, *"D,"* the loading is all at the top of the antenna. The maximum current is flowing in the total length of the antenna, and the strongest external field results from this action.

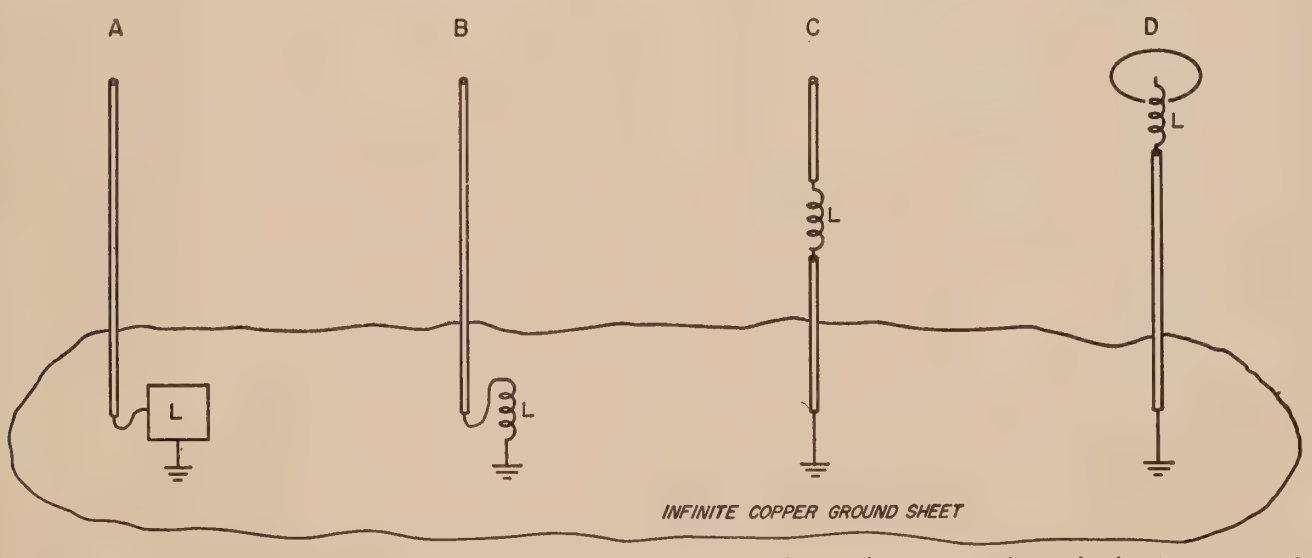


Fig. 6-1-C. A short vertical antenna may be resonated at a lower frequency through the insertion of an inductance or "loading coil." In "A" the loading coil is mounted in a shielded and grounded box. In "B" it is unshielded and mounted at the base of the antenna. In "C" it is unshielded, but mounted in the center of the vertical antenna. In "D" the coil is at the top of the vertical antenna with a "top hat" capacity arrangement.

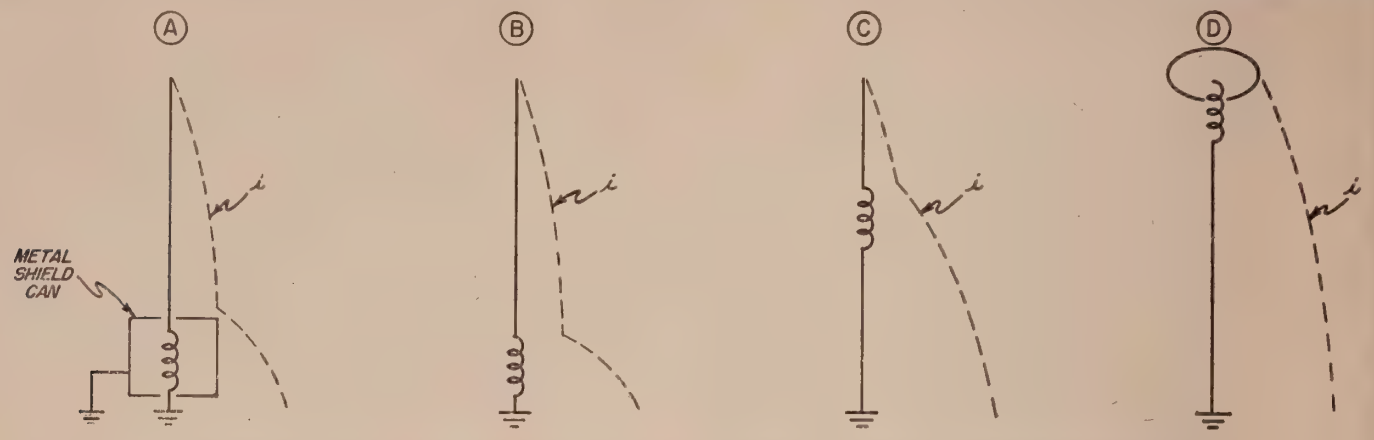


Fig. 6-1-D. Current distribution of the four types of "loaded" vertical antennas shown in Fig. 6-1-C.

The Eight Foot Whip and the Automobile

Some very important changes take place when this eight-foot vertical rod, or whip, is removed from the infinite copper ground plane and mounted on an automobile. The whip is not now operating with a low-loss ground system. It is operating against the car body, which is finite in size, and insulated from ground by the rubber tires of the automobile. The body of the car is not at ground potential, and therefore radiates some energy. This is important, as it alters the pattern of the whip antenna *(Fig. 6-1-E)* and also helps to raise the radiation resistance of the antenna system on the lower frequencies. Different measurements taken on a 9-foot whip at various frequencies are shown in *Fig. 6-1-F. Curve A* is the radiation resistance of the whip alone, over an infinite ground plane. *Curve B* is the radiation resistance of a typical *bottom loaded* whip mounted on the rear of an automobile. *Curve C* is the radiation resistance of a typical *center loaded* whip mounted on the rear of an automobile. *Curve D* is the actual measured *radiation resistance and loss resistance* curve for a center loaded whip, mounted on the rear bumper of a 1950 *Ford* coupe. The *loss resistance* consists of the r.f. resistance of the car and the antenna, and the losses in the loading coil. Of these losses, the loading coil losses are by far the most important. At 4 Mc., the loss resistance of this particular 9-foot whip and loading coil was 6 ohms, and the radiation resistance was 8 ohms. The load presented to the transmitter was 14 ohms. The efficiency of the antenna is 8/14 x 100, or 57%. This is extremely good efficiency at this frequency, since many 4-Mc loaded whips have efficiencies in the neighborhood of 5% to 20%.

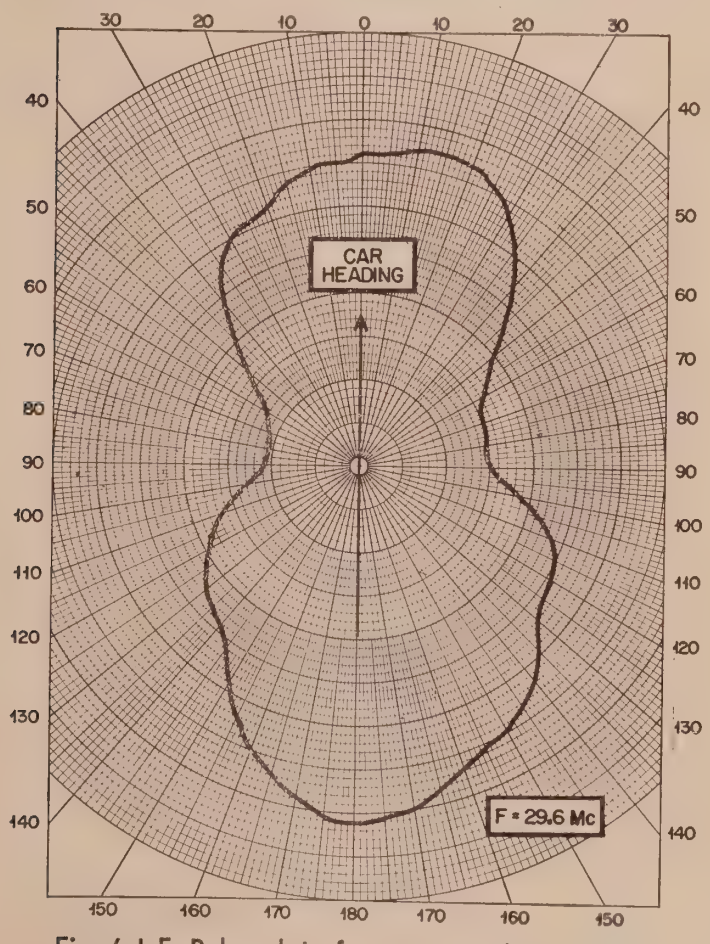


Fig. 6-1-E. Polar plot of a resonant short vertical antenna mounted on the left rear bumper of an automobile.

As the operating frequency of the loaded whip is raised, the size of the loading coil diminishes, and it is easier to construct an efficient loading coil of good *Q* without it being too large in size for a mobile installation. At 7 Mc., for example, with the proper loading coil, this same antenna has a coupling efficiency of about 70%. At 14 Mc., the efficiency rises to 85%, and at 28 Mc., the antenna will radiate practically all the power fed to it.

The importance of center loading mobile whips at low frequencies may readily be seen by comparing *Curves B* and *C*. The importance of having a good, efficient loading coil may be seen by comparing *Curves C* and *D*. A low efficiency loading coil would tend to push *Curve D* higher on the graph. The power wasted in the loading coil is represented by the vertical distance between *Curves C* and *D*. Using a loading coil that is 100% efficient would result in *Curve D* falling exactly on top of *Curve C*.

The Loading Coil

The all important loading coil is the heart of the loaded low frequency whip antenna. Its purpose is to cancel out the negative reactance offered by the short antenna to the tuning device. The shorter the whip antenna, compared ot a quarter-wavelength, the greater the negative reactance offered to the tuning device. A loading coil adds an equal and opposite amount of positive reactance to the antenna circuit. This

will neutralize out the negative reactance of the short whip, leaving only the radiation resistance of the whip and the inherent losses of the loading coil as the terminating load for the tuning device.

Unfortunately, most loading coils are far from perfect—they exhibit resistance as well as reactance. The ratio of the reactance to the r-f resistance is given by the symbol *Q*. A coil having a reactance of 1200 ohms (for example an 80-meter loading coil), and a resistance of 10 ohms is said to have a *Q* of 120. If this coil is used with an antenna having a radiation resistance of, say, 8 ohms, the coupling efficiency is then 8/(8+10) x 100 or 45%. Over half of the output power of the transmitter is lost in the loading coil. If the radiation resistance of the antenna is only 4 ohms (as it may well be with base loading), the coupling efficiency is then 4/(10+4) x 100 or 28%. This means that 72% of the transmitter output power is being lost in the loading coil. This power can only be dissipated in the form of heat. Small wonder that many loading coils burn up when 50 or 100 watts of r-f are applied to them!

To improve the efficiency of the loaded whip means increasing the radiation resistance of the antenna by using center or top loading, or raising the *Q* of the loading coil.

6.2—Practical Mobile Antennas

The usual mobile whip antenna used on the high frequency bands requires little or no loading to resonate it to the operating frequency. The radiation resistance of such resonant whip antennas for these frequencies is in the order of 25 to 35 ohms.

According to formula, a resonant whip for 10 meters should be between 8′4″ and 7′11″ long, depending upon the operating frequency in the 10-meter band. This is not strictly true, as a ¼-wave whip working in conjunction with a car body does not act as a true ground plane on 10 meters. The car body distorts the true

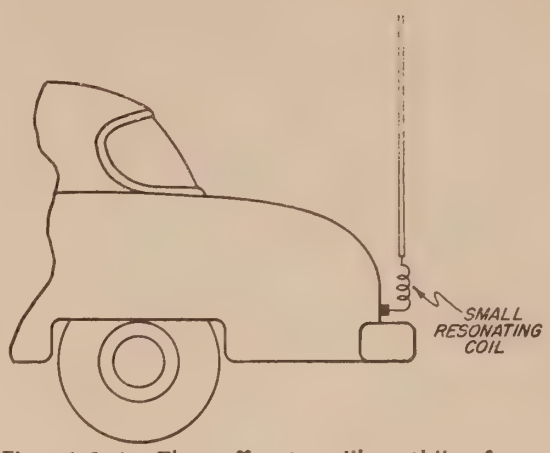


Fig. 6-2-A. The effective "length" of a whip antenna on 10 meters may be changed by adding a small resonating coil at the base.

circular pattern of the whip, and also alters the radiation resistance and the true resonant length of the whip. Typical measurements on several mobile installations indicate deviations from the accepted whip lengths of as much as one foot to obtain resonance at the desired frequency.

It is very important that the whip antenna be resonant near the operating frequency. If the whip length is fixed, additional "length" may be added to it in the form of a small coil, wound of No. 12 enameled wire, about ½″ diameter between the base of the whip and the coaxial line *(Fig. 6-2-A)*. The number of turns in this coil are adjusted until the antenna resonates at the correct frequency. If the whip is too long for the desired operating frequency, a variable condenser of 200 μμfd. capacity may be placed between the base of the whip and the coaxial feed line. This condenser should be adjusted until the antenna resonates at the desired frequency by coupling the whip to ground through a two-turn coil and using a grid dip oscillator.

Extended 10 Meter Whips

It is possible to use an extended length whip antenna on 10 meters for improved performance. A whip that is longer than ¼-wavelength may

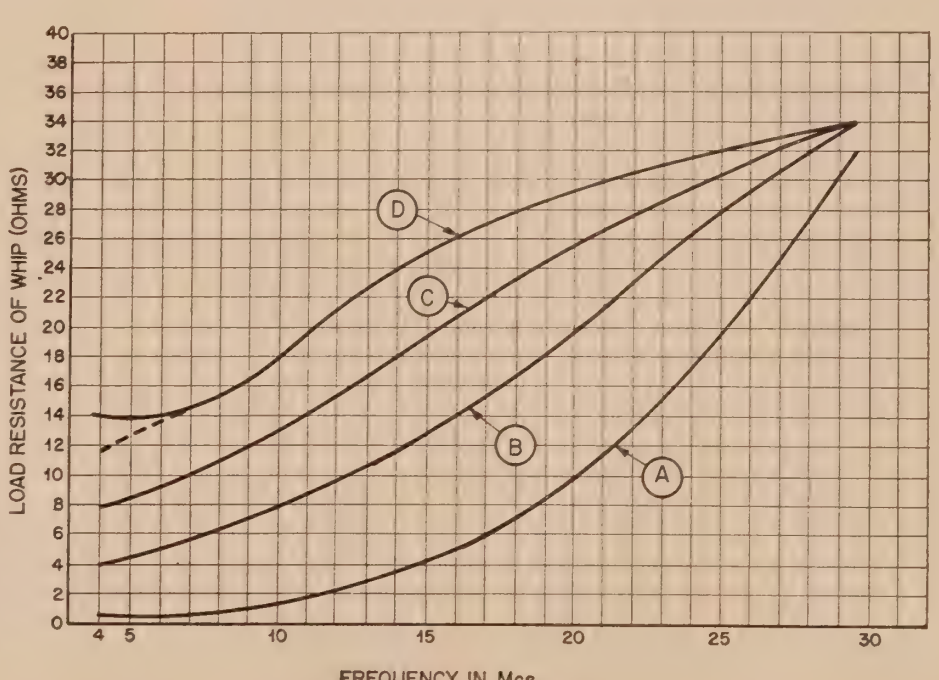
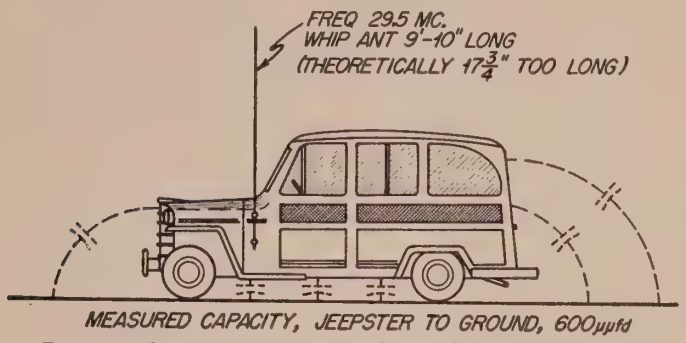


Fig. 6-1-F. Radiation resistance curves of typical 9-foot mobile antennas with various types of loading. Curve "A" is the resistance if the antenna were mounted above an infinite ground plane. Curve "B" shows a base loaded vertical mounted on an automobile. Curve "C" is the same antenna, but now center-loaded. Curve "D" is the radiation resistance and loss resistance of a center-loaded vertical antenna on a 1950 Ford coupe.



Frequently measurements show that a 10-meter whip may be considerably longer than indicated by theory. See text for details on coupling to car body and ground effects.

be series tuned to resonance, and will exhibit two desirable characteristics: The radiation resistance of the extended whip antenna is raised to a higher value than that of a ¼-wavelength whip, providing a better match for the coaxial feed system, and the radiating characteristics of the antenna are improved slightly with a resulting increase in gain of the antenna. This is a result of the lowering of the radiation lobe of the whip antenna due to the increased length, and also because the high current area of the antenna is farther removed from the body of the car. The over-all length of the 10-meter extended whip should be 10 feet for 52-ohm coaxial feed, and 11 feet for 72-ohm feed. The whip should be series tuned at the base by means of a variable condenser *(Fig. 6-2-B)*. The condenser, *C*, should be adjusted so as to grid-dip the antenna at the chosen operating frequency in the 10-meter band. The whip antenna will provide a very close match to the two feed lines if the above lengths are used, the VSWR will be very low, and the antenna will readily accept power over the whole 10-meter band.

15 and 20 Meter Mobile Antennas

A fifteen-meter ¼-wave whip antenna is approximately 11 feet long. It may also be operated on 10 meters, by the use of a series capacitor at the base as described above, thus providing excellent two band coverage (see *Fig. 6-2-C*). If a shorter whip is desired, a 10-meter whip about 8 feet long may be used, with some means of loading. Center loading is recommended, and for a standard two piece whip with a center loading form, 16 turns of No. 14 enamelled wire, 1″ diameter, and spaced to a winding length of 5¼″ will resonate the whip to the vicinity of the 21-Mc band. The whip may be adjusted to exact frequency by adjustment of the spacing of the turns of the coil.

An eight-foot whip may be loaded to 20 meters by the use of a small loading coil in the center of the antenna. A typical coil consists of 33 turns of No. 14 enamelled wire, 1″ diameter, and spaced to a length of 5¼″.

The loading coils for the 15 and 20-meter antennas should be wound on low loss polystyrene coil forms. Such a form is shown in *Fig. 6-2-D*.

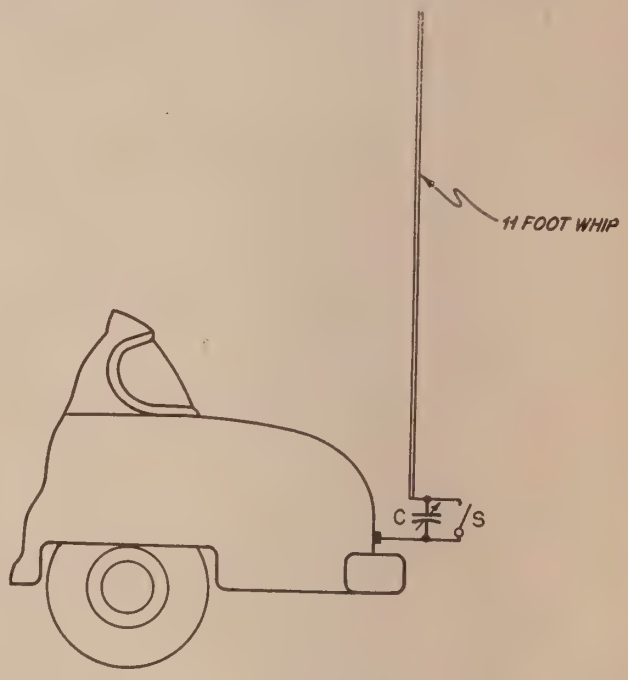


Fig. 6-2-C. The eleven foot whip antenna may be used for both the 10 and 15-meter bands. The whip is resonated at 10 meters by a series condenser and on 15 meters by shorting it out.

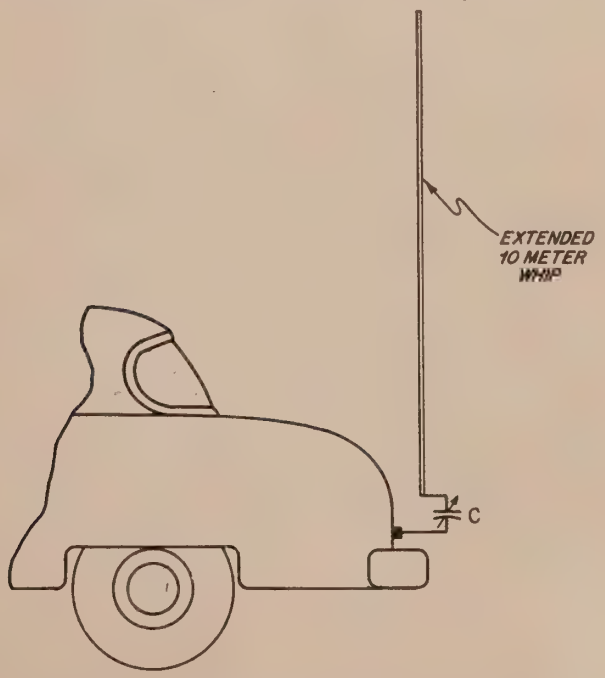


Fig. 6-2-B. Series resonating an extended 10-meter whip antenna.

For high power, No. 10 enamelled wire should be substituted for the specified No. 14. The radiation resistance of a center loaded 15-meter whip runs about 28 ohms, while the radiation resistance of a center loaded 20-meter whip runs about 18 ohms.

40 and 80 Meter Mobile Antennas

At a frequency of 40 meters, the loading coil in the usual eight-foot mobile whip starts to assume a dominant role in the efficiency of the antenna system. At higher frequencies, the amount of loading needed is quite small, and the loading coil has few turns and relatively high efficiency. The losses are low, and the antennas are very efficient. At 40 meters, the loading coil is quite large and the losses are apt to be high, unless certain precautions are taken. *Coil 1* of *Fig. 6-2-E* is an example of a high efficiency loading coil for 40 meters.

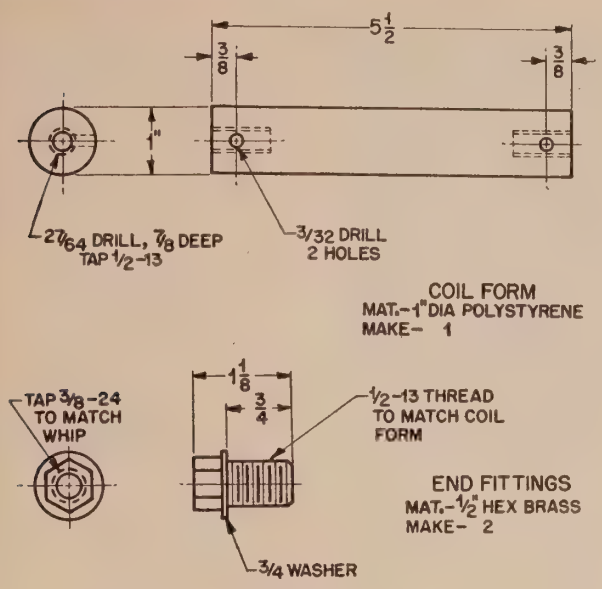


Fig. 6-2-D. Loading coil form suitable for use on 15 and 20 meters.

The radiation resistance of a 40-meter loaded whip is quite low, running in the vicinity of 10 ohms. Center loading should be used with the whip antenna.

Low Frequency Loading Coils

The literature on the design of high-Q coils discloses some interesting facts, not all of them favorable to the specialized coil required in a loaded antenna:

1. In general, the larger the coil, assuming a good form factor, the higher the Q.
2. Once the size of the form is established, the optimum wire size is somewhat smaller than the largest size that will give the necessary number of turns in the space available. In other words, use smaller wire and space the turns.
3. Reasonable liberties can be taken with form factor, and since a long slim coil can be more easily mounted on a car than a squat fat one, some departure from the dimensions can be tolerated.

As an experiment, W2CVV made several coil forms of dry maple, following these general specifications. The results were disappointing—the best coils wound on these forms had a Q of only 180. Although dry wood is supposed to have reasonably low loss, it was found that "reasonably low loss" was not good enough. Transferring one of the windings having a Q of 180 from the wood form to one of polystyrene immediately increased the Q to over 300.

A typical coil wound on a polystyrene form is shown in *Fig. 6-2-F,* and the constructional details are shown in *Fig. 6-2-G.* The core is a piece of 1¾" diameter polystyrene rod, undercut and threaded to take the winding of No. 18 enamelled wire spaced 16 turns per inch. The end fittings are made from brass, and securely anchored to the core by threading into it and then staking with a No. 8 screw tapped through the brass washer and on into the polystyrene. The fittings are threaded to accommodate the antenna sections that will be used. After final adjustment, the entire coil is covered by a polystyrene sleeve, 1¾" inside diameter, slipped on and cemented into place. Be sure to do a careful job of cementing since otherwise the coil will "breathe" and water will condense inside.

A "War Surplus" Loading Coil

The air-wound coils used with the surplus BC-610 transmitter may be modified for use as loading coils for whip antennas. For 80 meter operation, the 2.0-3.5 Mc. coil *(No. 1735)* should be used. The following changes should be made to the coil (see *Fig. 6-2-H*):

1. Remove the jack bar assembly.
2. The center tap connection should be broken and the variable coupling link connected in series with the two halves of the main inductance.

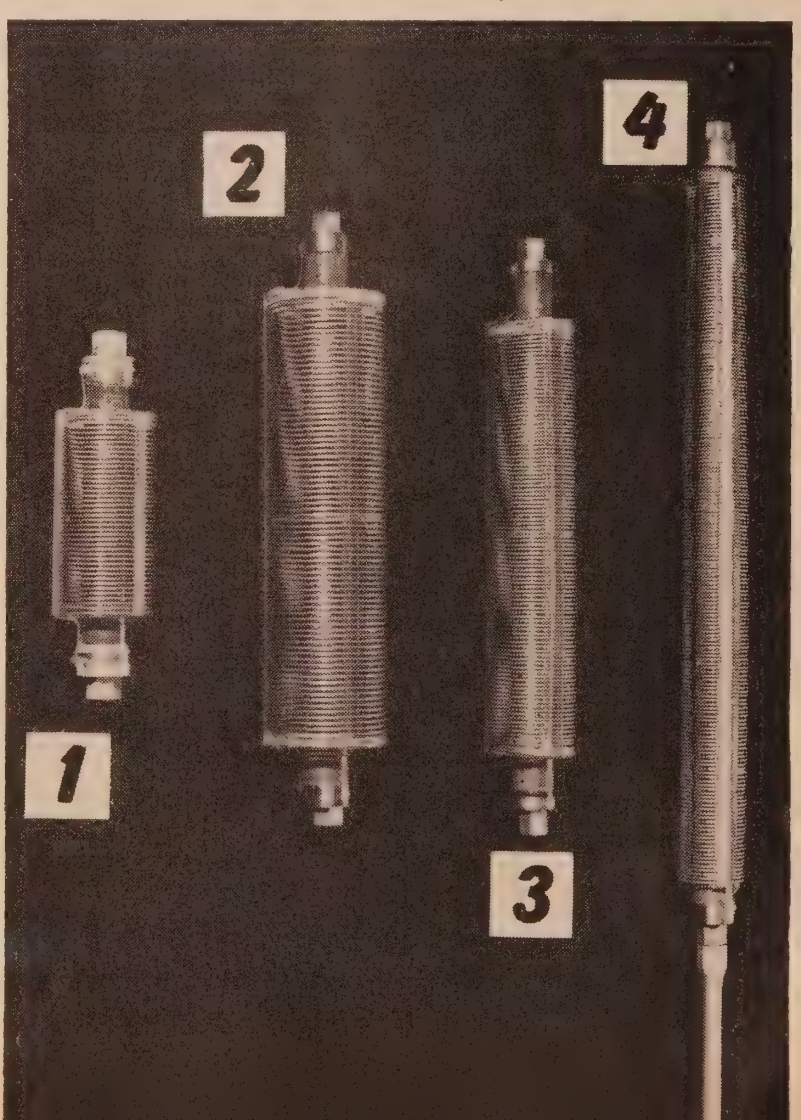


Fig. 6-2-E. High efficiency loading coils. Coil 1 is designed for the 40-meter band and is 2½ inches in diameter and 5 inches long. Coil 2 is a 75-meter loading coil made from B.&W. coil stock mounted on a one-inch phenolic rod. The coil is spaced away from the rod by polystyrene washers. Coil 3 is also a 75-meter loading coil with a two-inch diameter. Coil 4 is adjustable through the whip section at the end. It is designed for 75 meters and is 1½ inches in diameter.

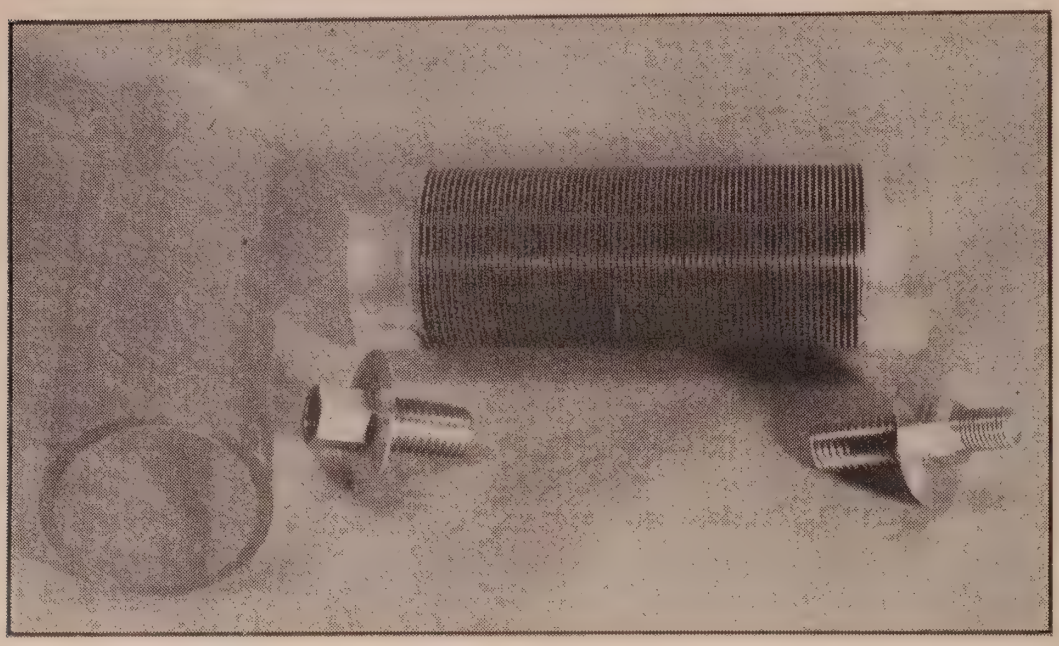


Fig. 6-2-F. The late W2CVV designed this polystyrene coil form in an effort to secure a maximum Q.

3. A hard wood core, 5½" long and 1¼" diameter should be turned on a lathe to act as a center supporting column.
4. Two end discs, 3⅞" diameter, and about ½" thick should be cut out of micarta, bakelite, or hard wood and mounted inside the fibre end rings of the BC-610 coil. Holes should be drilled through the fibre rings and wood screws driven through the holes into the circular wood block.
5. A suitable fitting should be made to fit into the center of the wood blocks to match the threaded ends of the whip. If an old loading coil is handy, these fittings may be stolen from it, otherwise they may be made as shown in *Fig. 6-2-D*.
6. This loading coil, with the usual 8 foot whip will tune just *outside* the high end of the 80-meter band when used in an average installation. A small base loading coil of a few turns may be added to lower the resonant frequency of the antenna to any point in the 80-meter band. This operation should be done with a grid-dip oscillator.
7. By swinging the variable center link, the resonant frequency of the antenna may be changed approximately 75 kilocycles. The antenna may be operated over a larger portion of the band than this, but there will be appreciable reactance reflected back into the loading system.

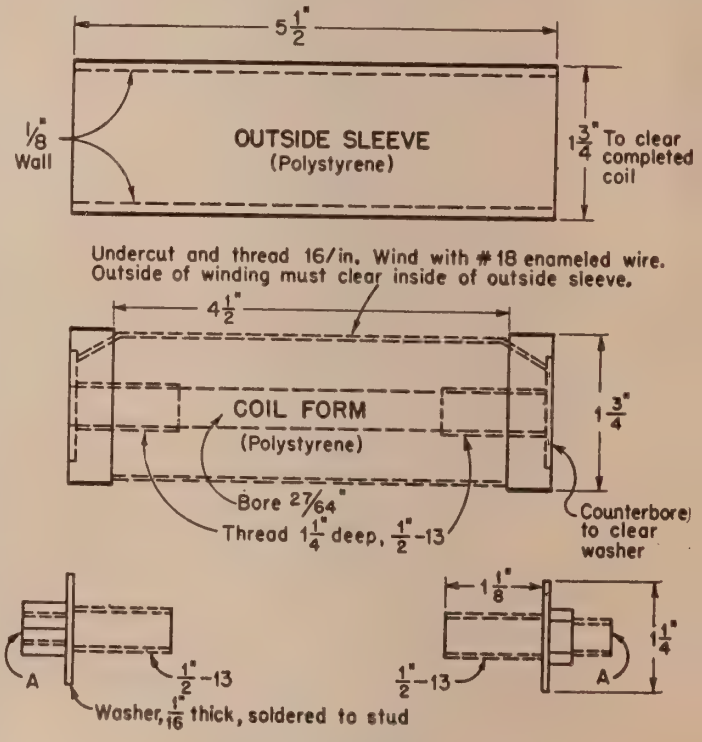
This loading coil has been used with transmitters running up to 300 watts power input with no appreciable signs of heating in the loading coil. The original coil form was impregnated, and will stand up well under adverse weather conditions.

High Efficiency Loading Coils

Several types of highly efficient loading coils for 40 and 80 meters, designed and built by W6LXA are illustrated in *Fig. 6-2-E*. The core, or supporting structure of the coil is a 1" diameter length of hollow phenolic rod. Fittings are placed on each end of the rod to match standard whip sections.

Coil 1 is designed to resonate at 7.2 mcs. It consists of a short length of *Barker and Williamson* airwound coil *No. 3906* (2½" diameter, No. 14 wire, 8 turns per inch). This airwound coil is spaced away from the phenolic rod by three polystyrene washers, one at each end of the coil, and one in the middle. This assembly provides a very rugged loading coil that will withstand hard abuse. It will handle 1000 watts of power at 7 megacycles with very little loss. The *Q* of this coil is 250.

Coils 2 and *3* are designed for 80 meters, and are built in the same manner as *Coil 1*. *Coil 2* uses *B. & W. 3906* airwound coil material



END FITTINGS
(Make from ½" hex. brass)

Note A: *Usually 3/8"-24 (G.E.) or 7/16"-24 (Premax) thread to fit mounting base and antenna.*

Fig. 6-2-G. Construction details of the loading coil shown in photograph above.

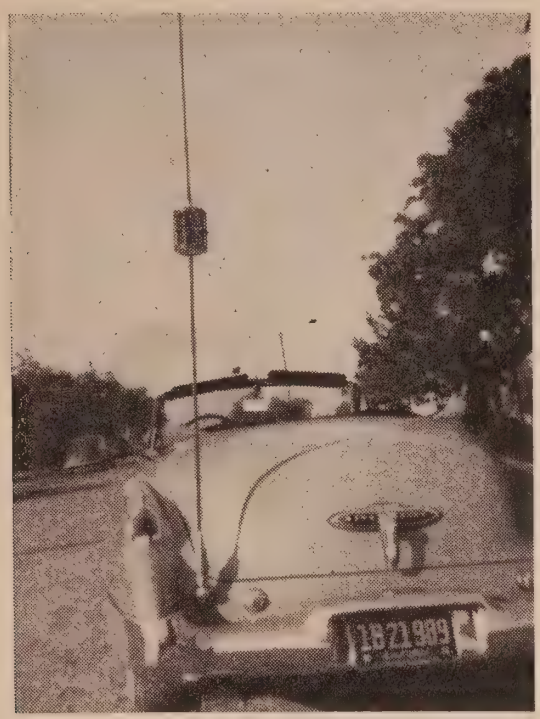


Fig. 6-2-H. A "war surplus" loading coil.

(*Q* : 350), while *Coil 3* uses *B. & W. 3907* (2" diameter) coil material (*Q* : 315).

Coil 4 is an experimental coil that has produced exceptionally good results. The theory of operation is discussed below. The center support of the coil is a 20" length of hollow phenolic rod. The coil is 1½" in diameter, and spaced away from the rod by three long strips of ¼" x ¼" polystyrene that run the length of the coil. These strips are spaced 120 degrees around the phenolic form. The coil is air-wound of No. 16 wire, 9 turns to the inch. The coil is 17¼" long, and has 155 turns.

The *Q* of this coil (240) is not as good as the shorter, larger diameter coils, but its other properties greatly outweigh the importance of the lowered *Q*.

The Radiating Loading Coil

Coil 4 of *Fig. 6-2-E* was wound with a rather unusual idea in mind. The coil was made small in diameter, and very long. This, of course, spoiled the form factor and resulted in a decided drop in the *Q* of the coil. It was hoped that the actual *radiation* of r-f energy from the coil would be enough to overcome the lowered efficiency of the coil.

This theory was borne out in actual field strength measurements. The long, thin coil repeatedly gave higher field strength measurements than shorter coils of better form factor and higher Q. This would indicate that the coil is actually radiating energy in conjunction with the whip. The radiation resistance of this antenna is also appreciably higher than that of antennas using more conventional loading coils. Using such a coil as illustrated in *Fig. 6-2-E*, a transmitting impedance of 17 ohms was measured for an eight-foot whip at 4 Mc., and a calculated over-all efficiency of 60% was obtained for the antenna system.

Capacity "Hats"

If a longer whip section is used above the loading coil, a greater total value of current will flow through the loading coil and the lower section of the antenna. Since the whip is longer, the loading coil can be made smaller, with less inherent losses. A whip length above the loading coil of six feet is just about the practical maximum for ordinary automobile driving. An electrical length greater than this can be obtained by the use of a top loading disc, or capacity "hat" *(Fig. 6-2-I)*. This hat increases the effective capacity of the top section of the whip to ground and effectively "lengthens" the top section of the antenna. For best results this hat should *not* be located directly above the loading coil, as the capacity of the hat will then appear across the loading coil, rather than from the hat to ground. At all times, the capacity across the loading coil should be kept as low as possible. This rules out the use of metal coil cans or hats mounted in the vicinity of the coil. They will merely increase the distributed capacity across the coil, and do little to increase the efficiency of the antenna system.

The Medicine Man Loading Coil

The March/April, 1953 issue of the *General Electric Co.* magazine "Ham News" contains an interesting article on a loading coil mounted in a 16-oz. polythylene bottle. It is pictured in *Fig. 6-2-J* with permission of the *G.E. Co.*

The coil is wound on a polystyrene form and is protected from the weather by the round bottle. The trade name of the bottle is *Plaxpac*. Such bottle may be obtained at some drugstores,

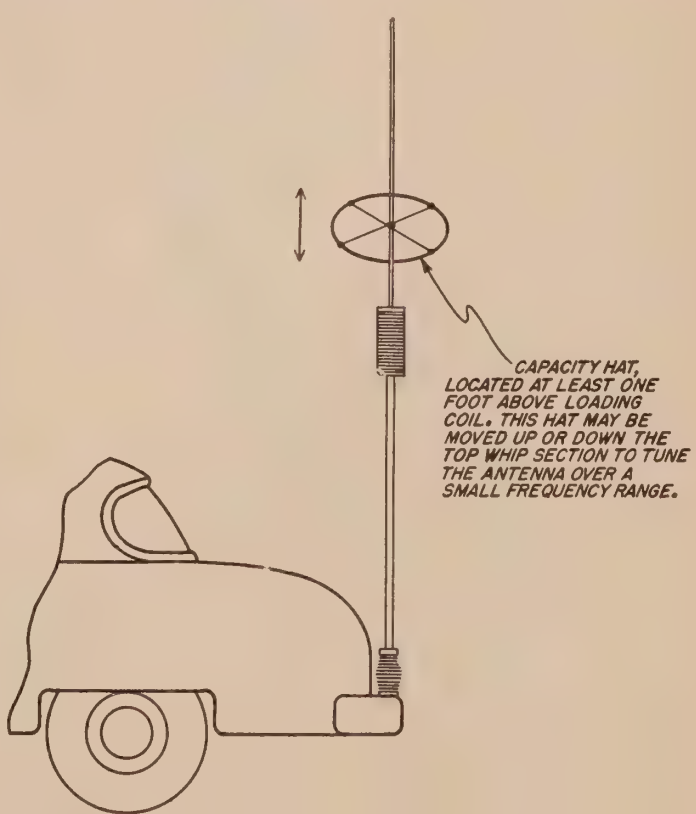

CAPACITY HAT, LOCATED AT LEAST ONE FOOT ABOVE LOADING COIL. THIS HAT MAY BE MOVED UP OR DOWN THE TOP WHIP SECTION TO TUNE THE ANTENNA OVER A SMALL FREQUENCY RANGE.

Fig. 6-2-I. Use of a capacity "loading hat." The "hat" is made of one-sixteenth inch diameter steel rods with four or six spokes. The diameter is between 8 and 14 inches and the hat is locked into place with "Allen" set screws.

or from a plastic bottle distributor. Modification of the bottle offers no problems. Simply drill a hole in the center of the bottom to pass the top fitting of the coil and then cut off the top of the bottle so as to leave an opening which will fit snugly—but not airtight—over the bottom end of the coil form.

160-Meter Loading Coils

The 160-meter band is rapidly gaining in popularity as a mobile band. The attenuation of vertically polarized signals in the 80-meter region during daylight hours is very pronounced (see *Fig. 6-2-K*) while, during the evening hours, the heavy QRM on the 80-meter band makes mobile operation very difficult.

The ground wave propagation characteristics of 160 meters is considerably better than that observed around 4 Mc. at any given distance. Contrary to some popular opinion, a loaded 8-foot whip antenna can be made to work out on this band.

A 160-meter loading coil is shown in *Fig. 6-2-L*. Two different types are shown. Either one will work satisfactorily, and the choice between the two can probably be made on the basis of available materials.

Fig. 6-2-J. This loading coil has been mounted in a plastic polyethylene bottle to protect it from the weather. It is capacity tuned with a "sardine can opener." A one-half inch wide copper strap is used to tune the coil.

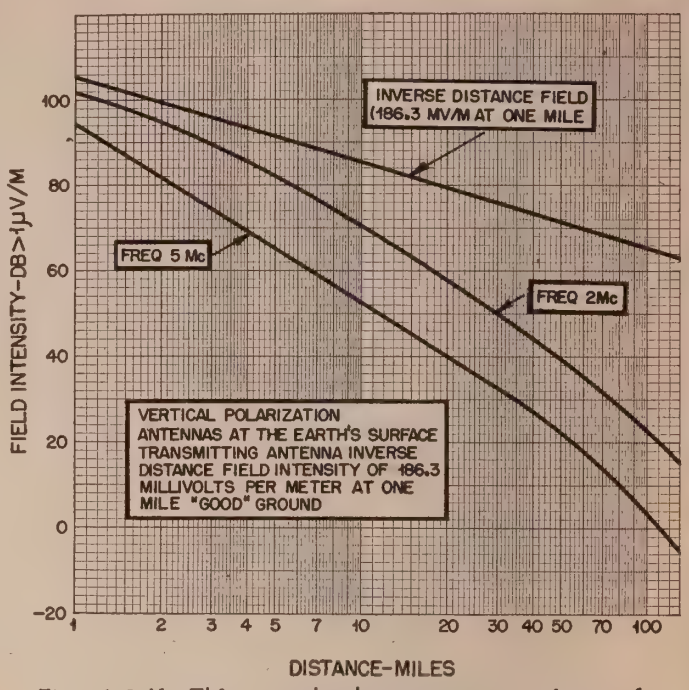


Fig. 6-2-K. This graph shows a comparison of field strengths over good ground for frequencies equivalent to the 160 and 80 meter bands. Note that at 10 miles the 160 meter field is approximately 10 db. stronger than the 80-meter field.

Summary

In general, the following rules should apply to the over-all design of the loaded whip antenna:

Rule 1—For greatest coupling efficiency and highest radiation resistance, the loading coil of a whip antenna should be mounted as far up the whip as is physically possible.

Rule 2—If the loading coil is mounted more than half way up the whip antenna, some form of capacity top loading should be used.

Rule 3—The portion of the antenna above the loading coil should exhibit a minimum of shunt capacity across the coil. This means that any capacity loading device should be mounted at least a foot above the loading coil.

Rule 4—It is better practice to increase the length of the whip above the coil than it is to use lumped capacity loading. This will produce a minimum of shunt capacity across the loading coil.

Rule 5—The diameter of the loaded whip antenna should be as great as physically possible.

Operation of Low Frequency Loaded Whip Antennas

One of the penalties that must be paid for high Q and high efficiency in the antenna system is that the tuning of the antenna becomes extremely sharp. It is thus necessary to adjust the loading accurately, and to adjust it for each significant change in operating frequency. To put this in practical terms, if the frequency is shifted plus or minus 5 kc. without reloading, no appreciable loss will result; 10 kc. and the output and transmitter plate current will start to drop off; 15 or 20 kc., and the performance will seriously suffer. Obviously some convenient means must be provided for adjusting the antenna loading or some other portion of the circuit to tune out the antenna reactance at each frequency setting.

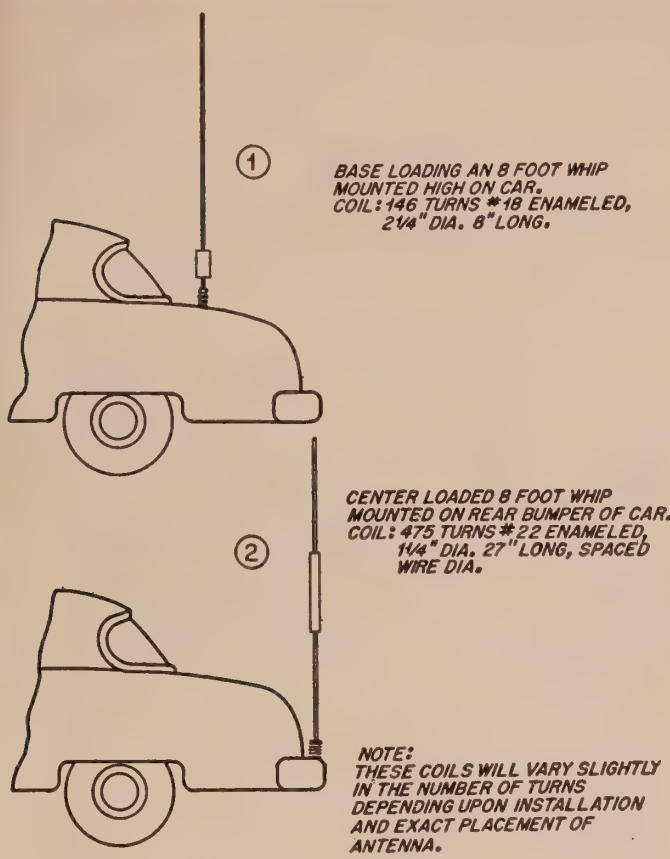

1
BASE LOADING AN 8 FOOT WHIP MOUNTED HIGH ON CAR. COIL: 146 TURNS #18 ENAMELED, 2¼" DIA. 8" LONG.
2
CENTER LOADED 8 FOOT WHIP MOUNTED ON REAR BUMPER OF CAR. COIL: 475 TURNS #22 ENAMELED, 1¼" DIA. 27" LONG, SPACED WIRE DIA.
NOTE: THESE COILS WILL VARY SLIGHTLY IN THE NUMBER OF TURNS DEPENDING UPON INSTALLATION AND EXACT PLACEMENT OF ANTENNA.

Fig. 6-2-L. Two variations of a 160-meter loading coil. Either method of loading may be used with assured equivalent results.

On 40 meters, the loading coil is smaller, and the whip is longer in proportion to the wavelength. Changes in frequency of plus or minus 30 kilocycles of the operating frequency may be made with no appreciable loss of antenna circuit efficiency. However, for changes of the order of 50 to 100 kilocycles, some means of varying the antenna loading must be incorporated in the antenna system.

6.3—Maintaining Antenna Resonance

On 10, 15 and 20 meters, the whip antenna will easily tune the complete amateur band with little trouble. No external means of altering the electrical length of the antenna is necessary. On 40 meters, the loaded whip antenna will tune over about half the phone band, but some means of varying the loading inductance is necessary if the complete phone band is to be covered in an efficient manner. On 80 meters, the effective band width of a loaded whip is very narrow, and some means of rapidly and conveniently retuning the antenna to resonance from the car should be employed.

The antenna resonant frequency may be changed either by altering the length of the antenna whip, or by varying the inductance of the loading coil. The first method is practically an impossibility to accomplish by remote control. A whip adjuster, such as shown in *Fig. 6-2-E* may be placed between the loading coil and the top whip section to allow an adjustment of four inches or so in the whip length, but the car must be stopped and the length change made by hand.

The antenna resonant frequency may be remotely adjusted, as shown in *Fig. 6-3-A,* by employing only partial loading in the antenna itself, and then by making up the difference with a variable inductor mounted in the car trunk.

A rotary inductance coil, such as the *Barker and Williamson No. 3852* is ideal for this purpose since it may be easily controlled from the operator's position by means of a flexible tuning shaft. *(Fig. 6-3-A)*

Referring to *Fig. 6-3-B,* the inductance of *L2* should be made as small as possible to keep as much of the antenna system outside the car as possible. This will reduce losses in the internal inductor, and at the same time will keep most of the lower impedance, or highest current portion of the antenna system out in the clear

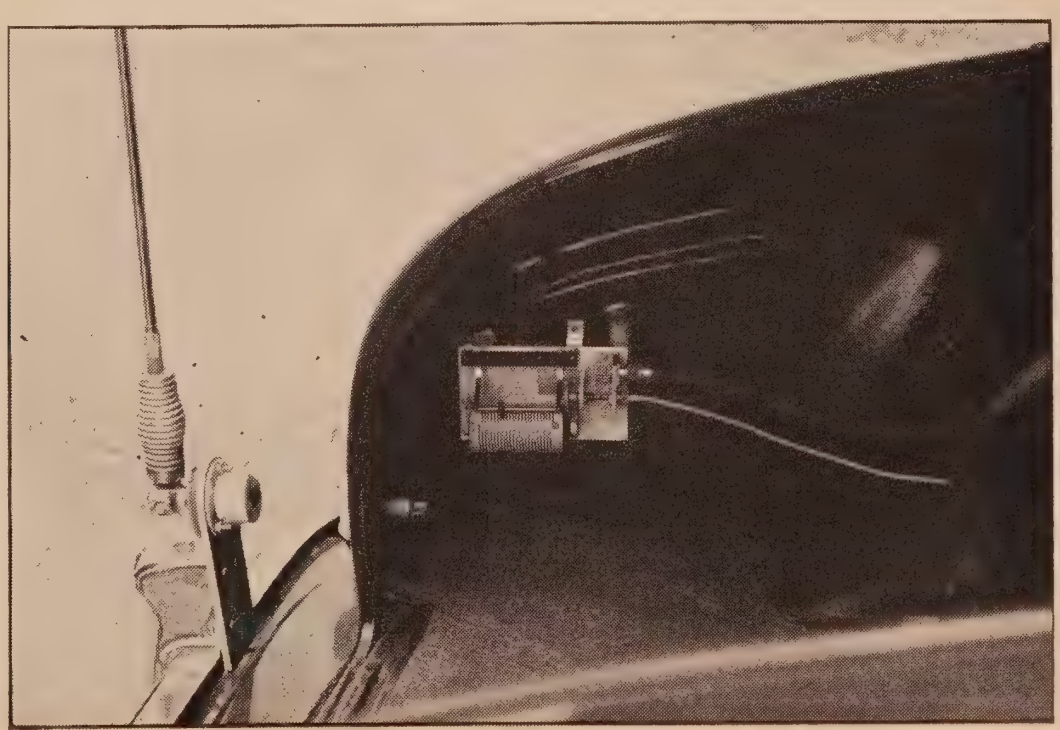


Fig. 6-3-A. Partial base loading is used by W2AEF to obtain maximum coverage with an 80-meter loaded whip. The variable loading coil was made from the antenna coil of an SCR-274N command transmitter. It may be replaced with a B.&W. #3852 variable inductance.

where it has a better chance to radiate. *L1* should be adjusted so that resonance is realized at the highest frequency to be used when *L2* is set for minimum inductance. In order to preserve the *Q* of *L2,* the tap should be connected so that the unused turns are not short circuited.

Initial tuning may be accomplished through the use of a grid dip oscillator, the base of the whip antenna being shorted to ground during the measurement. All adjustments should be made with the trunk lid closed.

As the inductance of *L2* is increased, the resonant frequency of the antenna system will be lowered. The additional losses introduced into the circuit by the base loading coil may be considered negligible when compared to the advantage gained by always having the antenna tuned to resonance.

An important requisite for this as well as for any other mobile antenna installation is that the car body be made as good a ground system as possible. To do this, all sections of the body should be bonded together. The bumpers, fenders, chassis, motor, etc. should be all bonded with flexible copper braid.

If the antenna is mounted at a place which requires a lead to be run between it and the inside of the trunk, a low capacity ceramic insulator should be used at the feed-through point.

With this method of tuning, *L2* should be mounted well clear of the car body to keep the shunt capacity low. If the variable tuning capacitor is used, *L2* may be mounted outside the car body at the base of the antenna.

A gear reduction drive, such as the *Millen No. 10,000* should be used between the rotary inductor and the flexible shaft.

A number of different lengths of flexible cable may be found on the surplus market. Speedometer cable may also be used for the flexible control shaft.

During operation, the antenna should be tuned to resonance as indicated by the point of maximum loading of the final amplifier. An alternative method of resonance indication is the use of a simple r-f field indicator, such as the *Crystal Ball,* described in *Chapter 7.*

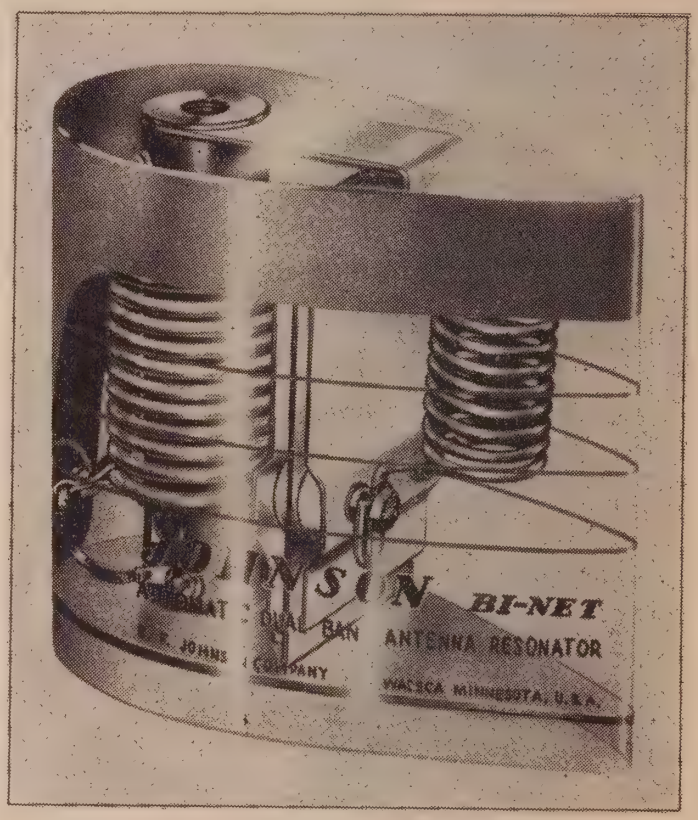


Fig. 6-4-A. The BI-NET dual band loading coil mounts in the center of a standard mobile whip type antenna. It permits the operator to change bands while in motion without adjusting the antenna. The assembly is enclosed in a streamlined weatherproof plastic case.

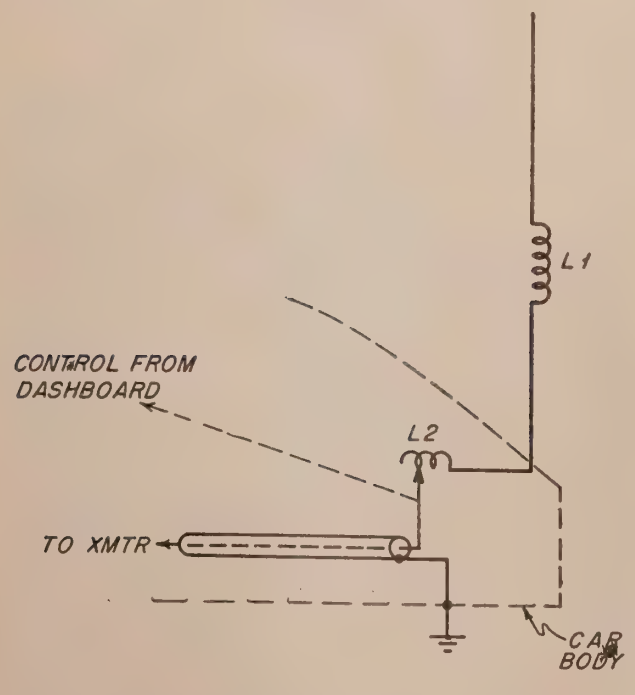


Fig. 6-3-B. Electrical equivalent of the variable loading idea shown in Fig. 6-3-A.

6.4—The BI-NET Dual Band Antenna

The *Bi-Net* antenna tuning network is a novel variation of the usual single-band loading coil. It is developed and marketed by the *E. F. Johnson Co.* (patents pending). This type of antenna provides multi-frequency operation with only one antenna and transmission line without the use of mechanical switching devices. Adjustable network elements permit easy and accurate tuning in the installed position on the automobile *(Fig. 6-4-A).*

A schematic of the *Bi-Net* is shown in *Fig. 6-4-B.* The antenna illustrated will work on any two amateur bands, with the lower of the two frequencies designated as *F1* and the higher frequency as *F2.* (For example, let *F1* be 14 Mc., and *F2* be 28 Mc.)

The whip length, *X* plus *Y,* is so chosen as to be resonant at *F2.* The values of *L2* and *C1* are such that series resonance at *F2* occurs between terminals *A* and *B.* Since a series resonant circuit offers zero impedance at the resonant

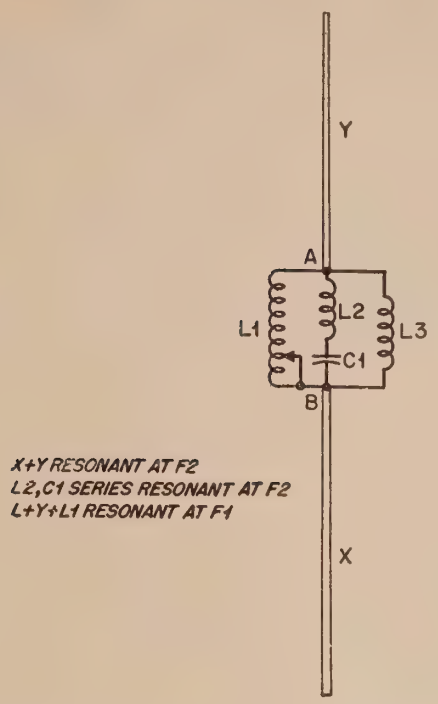


Fig. 6-4-B. Electrical equivalent of the BI-NET.

frequency, an electrical short is provided across points *A* and *B*, thus leaving the whip antenna (*X* plus *Y*) resonant at *F2*. Because there is zero impedance across points *A* and *B* at frequency *F2*, circuit elements *L1* and *L3* may be placed across points *A* and *B* without effect on the antenna behavior at *F2*.

Circuit element *L3* is of a value which, in conjunction with *L2* and *C1*, forms a parallel resonant circuit across points *A* and *B* at *F1*. A parallel resonant circuit will present infinite impedance across points *A* and *B* at *F1* so that the combination of *L2*, *C1* and *L3* is effectively not connected across points *A* and *B* at *F1*. The open circuit between points *A* and *B* at *F1* is now closed by the addition of *L1*, which, in conjunction with the *X* and *Y* sections of the whip antenna resonates to *F1*. The parallel combination of *L1*, *L2-C1* and *L3*, in itself is not resonant at *F1*.

In practical application, *C1* or *L2* is made variable to provide adjustments at *F2*. *L1* and *L3* are combined in their parallel equivalent into one coil, and the resultant inductor is made variable to provide adjustment at *F1*.

Assembly and Tuning of the Bi-Net

Whip sections *X* and *Y* are the upper and lower portions of a split ten-meter whip. *L2-C1* is series resonant at 10 meters. The adjustments are made by shorting points *A* and *B* and resonating *L2-C1* by means of a grid dip oscillator to the middle of the 28-Mc band. The short across *A* and *B* should be removed and the overall antenna resonance adjusted to the operating frequency in the 28 mc. band. This may be done by trimming the top section *Y* until resonance is obtained at the desired frequency.

The final step is to adjust the tap on *L1* so that the over-all system is resonant to the desired frequency in the 14-Mc band.

Although this example pertains to 10 and 20-meter operation, other band combinations are possible.

A Three Band Mobile Antenna

The *Bi-Net* idea may be expanded to three band operation, by the use of two network assemblies, mounted at the center of the whip antenna, as shown in *Fig. 6-4-C*. Frequencies *F1, F2* and *F3* are in increasing order. *L2-C1* is series resonant at *F3; L4-C2* is series resonant at *F3;* and *L5-C3* is series resonant at *F2*. Network *L1, L2, C1* is the same as the network shown in *Fig. 6-4-B*. Only one inductor is used for *L1* and *L3*, and is the parallel equivalent of the two.

L3 of *Fig. 6-4-C* is electrically shorted on *F2* and *F3* by the series tuned circuits at *A* and *B*. *L3* is so chosen to resonate the entire system at *F1*. Both *L1* and *L3* are electrically shorted out at *F3*, leaving only the resonant length of the whip at this frequency. *L1* resonates the system at *F2*. In this manner the antenna will act as a quarter-wavelength whip on three amateur bands.

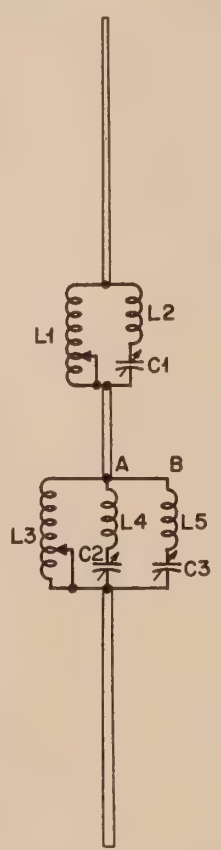


Fig. 6-4-C. A three-band whip antenna using two BI-NET assemblies.

Chapter Seven

Test Equipment

7.1—Mobile Test Equipment

Certain pieces of test equipment are an absolute necessity for efficient mobile operation. Others are handy auxiliary aids that make mobile operation a pleasure, rather than a frustrating experience. The purpose of this chapter is to describe pieces of test equipment that are eminently suited to mobile work, and to show how they may be used in the most effective manner.

The Grid Dip Oscillator

The grid dip oscillator, or "grid dipper" is a calibrated, low power oscillator equipped with a meter which indicates the oscillator activity. When this oscillator is coupled to a circuit which is capable of absorbing r-f power from the oscillator, the activity of the oscillator will decrease. If the load circuit is tuned, it will accept power more readily at the particular frequency where it is resonant. If the grid dipper is coupled to a non-resonant type of load (such as a low inductance link feeding a pure resistance) power will be accepted by the load over a wide range of frequencies, and the effect on the oscillator will be a general reduction of the meter reading of the dipper regardless of the frequency to which the grid dipper is tuned. If, on the other hand, the grid dipper is coupled to a low-loss parallel tuned L/C circuit, power will be absorbed most efficiently at the resonant frequency of the tuned load circuit, and a well defined dip in the oscillator grid current will be noted as the grid dipper is tuned across this frequency. The higher the Q of the coupled circuit, the sharper the dip will be.

Mobile whip antennas are high Q circuits, the loaded antennas for 80 and 40 meters having extremely high Q. To check the resonant frequencies of these high Q antennas using a grid dipper is an exacting task, since it is often hard to obtain a readable dip on the meter. For best results, the feedline should be removed from the antenna, and the base of the loaded whip should be grounded through a one-turn link coil, and the dipper closely coupled to this coil. A three-turn coil should be used for 80 meters. The dipper should be slowly tuned across the whip frequency, and the meter watched for a short, sharp kick as the resonant frequency is passed. The resonance frequency should be approached from both the high frequency and low frequency sides of resonance, as often the meter kick is more pronounced as resonance is approached from one particular side.

When the resonance point has been found, the coupling between the dipper and the link should be decreased until there is a barely discernible kick as the grid dipper is tuned through resonance. A series of resonance readings should now be made, logging the exact frequency of the dipper with the aid of a frequency meter or an accurately calibrated receiver. If ten accurate and separate readings are made, and the average of these readings taken, the resonance frequency of an 80-meter loaded whip can be read to about 5 kilocycles.

Since the average pass band of an 80-meter loaded whip is of the order of perhaps 20 kilocycles, it can be seen that great care should be taken when determining the frequency of the antenna by the use of a grid dip oscillator.

On the higher frequency bands the problem is less acute. The Q of the antenna system is lower, the whip has a broader frequency response and the grid dipper will therefore indicate a broader, easier to read null.

Construction of a Simple Grid Dip Oscillator

A simple, inexpensive grid dipper is illustrated in *Fig. 7-1-A*. This dipper covers the range of 2.8-35 Mc., covering all mobile frequencies up through the 10-meter band.

A single 6C4 is used as an electron coupled oscillator, using a 0-1 milliammeter in the grid circuit as a resonance indicator. A 6E5 electron eye tube may be used as an inexpensive substitute for the meter, if desired.

The grid dipper should be built up in a small shielded box *(Bud Minibox)*, with the grid dipper coil socket mounted on the rear of the

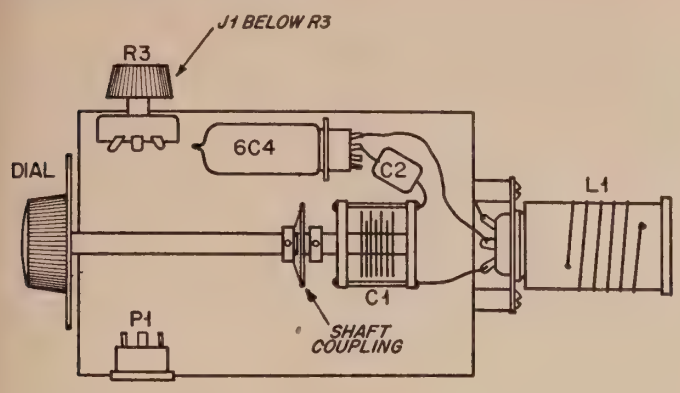
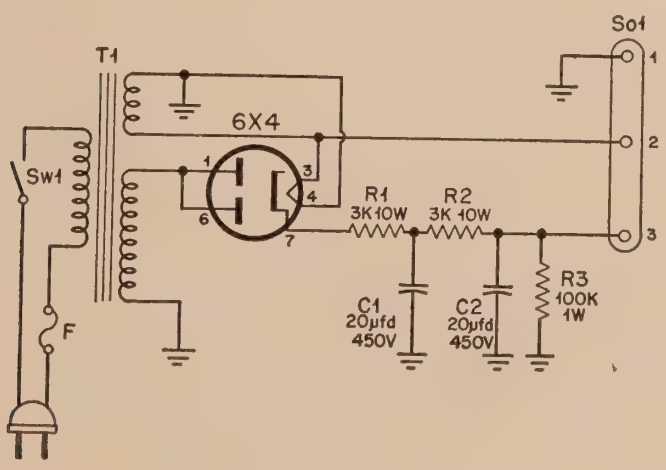


Fig. 7-1-C. Suggested mechanical layout of the inexpensive grid dipper described in the text.

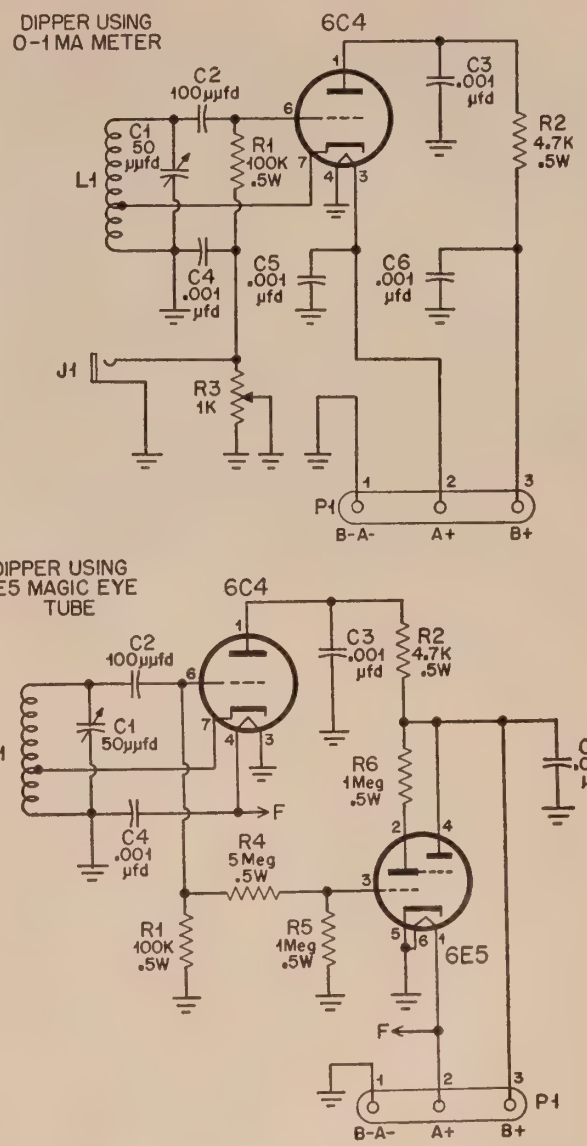
box on ½" metal spacers. Spacing the coil away from the box in this way allows the coil of the dipper to be brought closer to the testing circuits before the box of the dipper gets in the way. The two leads from the coil to the grid and cathode of the 6C4 are brought through a ½" hole drilled directly beneath the coil socket. The ground end of the coil is connected to the bolt that holds the coil socket.

C1 is mounted directly in front of the coil socket, and coupled to the *National AM* dial by means of a shaft coupler and a short length of ¼" brass rod. The 6C4 tube socket is mounted in front of *C1,* on a small angle bracket cut from scrap aluminum. *Pin 4* of the 6C4 is grounded, and *C3* connects between *pins 1* and *4*. *C2* connects between *pin 6* and the stator of *C1,* and *R1* connects from *pin 6* of the 6C4 socket to an insulated tie point. *C4* connects from this tie point to the ground. *C5* connects from *pin 3* to *pin 4* of the socket. *R2* is attached to *pin 1,* and the opposite end goes to an insulated tie point.



C1—C2—dual 20/20 μfd., Sprague TVA-2730.
F—fuse, 1 amp., 3AG.
R1, R2—3000 ohms, 10 watt, wirewound.
R3—100,000 ohms, 1w.
So1—Jones, socket, S303-RP.
Sw1—S.p.s.t. switch.
T1—120v. at 50 ma., 6.3v. at 2.0 amp., Merit P-3045.

Fig. 7-1-B. Power supply for the dipper shown in Fig. 7-1-A.



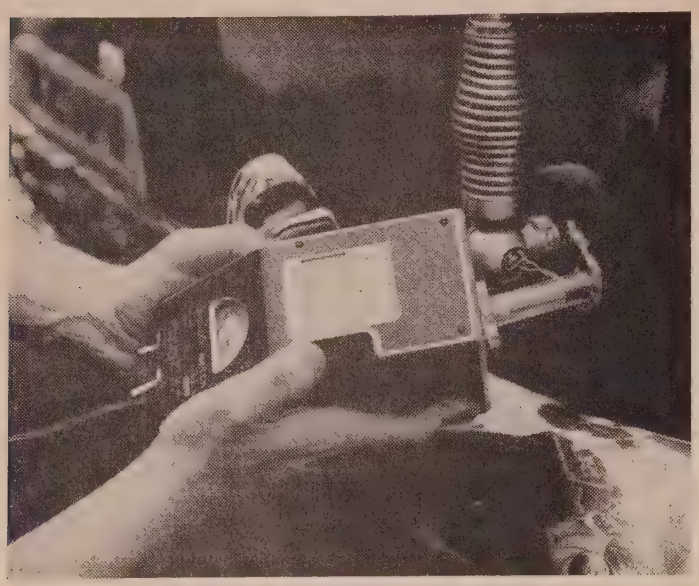
C1—50 μμfd., Bud MC-1853.
C2—100 μμfd., silver mica.
C3, C4, C5, C6—0.001 μfd., ceramicon Erie 801-001.
J1—Jack, open circuit.
P1—Socket Cinch-Jones, S-303RP and plug P-303CCT.
R1—100,000 ohms, ½w.
R2—4700 ohms, ½w.
R3—1000-ohm potentiometer.
R4—5.0 megohms, ½w.
R5, R6—1.0 megohm, ½w.
Dial—National AM, scale #2.

Fig. 7-1-A. Two versions of a simple inexpensive grid dipper covering the range of 2.8 to 35 megacycles.

Sensitivity control *R3* is mounted on the side of the box, as is *J1*. Any 0-1 ma. d-c meter may be plugged into *J1* to act as an indicating device. Condenser *C6* is mounted on the back of *P1,* from *pin 3* to *pin 1*. *Pin 1* is grounded.

The grid dipper requires 6.3 volts at 0.15 amperes a-c or d-c for the filament, and 90 to 250 volts d-c at 5 milliamperes for the plate supply. This power may be "borrowed" from the converter power receptacle on the car receiver, or a separate power supply, such as shown in *Fig. 7-1-B* may be used.

If a 6E5 electron eye tube is incorporated in the dipper, the filament drain is increased to 0.5 amperes. The plate current drain will then be 7 milliamperes.



This is the method of coupling a grid dipper to a mobile antenna to find the resonant point. Details on grid dipper utilization appeared in the January, 1953 issue of CQ.

A suggested mechanical layout for the dipper is shown in *Fig. 7-1-C*.

When the dipper is completed, it should be checked and calibrated against an accurate frequency meter or receiver.

For additional information on the general operation and use of grid dippers, refer to the January, 1953, issue of *CQ Magazine*.

COIL NO.	FREQUENCY RANGE	WINDING
1	2.8 – 4.9 Mc	34½ TURNS #35 DCC TAP 1½ TURNS FROM GROUND
2	4.6 – 8.0 Mc	21½ TURNS #24 E TAP 1 TURN FROM GROUND
3	7.6 – 13.2 Mc	13 TURNS #24 E TAP 1 TURN FROM GROUND
4	12.6 – 22 Mc	6¾ TURNS #22 E TAP ¾ TURN FROM GROUND
5	20 – 33 Mc	5 TURNS #22 E SPACED ½" OVERALL TAP ¾ TURN FROM GROUND

NOTE – ALL COILS WOUND ON 1⅜ DIA FORM (ICA #2158)
ADJUST SPACING OF TURNS ON COIL 5 TO RESONATE AT 20 Mc WITH C1 FULLY MESHED

Coil Data for the Circuits shown in Fig. 7-1-A.

7.2—The Antennascope

The *Antennascope*, designed by W2AEF and described in the September, 1950, issue of *CQ* Magazine, is a modified bridge circuit that will measure the resistive impedance of an antenna. It is invaluable in adjusting mobile whip antennas.

The *Antennascope* is connected between a suitable r-f source such as a grid dipper, and the antenna to be measured. One side of the r-f bridge of the *Antennascope* is a potentiometer that is calibrated in ohms. When the bridge is balanced, and this potentiometer is set for a null reading, the resonant frequency of the antenna may be determined from the grid dipper, and the radiation resistance of the antenna may be read directly from the calibrated potentiometer on the *Antennascope*.

The impedance range of the *Antennascope* described herein is 5 to 500 ohms, and it is useful over the range of 2-60 Mc.

Construction

The circuit of the *Antennascope* is shown in *Fig. 7-2-A*. *R2* and *R3* are ½-watt carbon resistors, 200 ohms each. A handful of 200-ohm resistors should be checked with an ohmmeter to get two that are close to each other in value. The exact resistance value of the two is unimportant, it may be anywhere near 200 ohms, but the two resistors should have the *same* ohmic value, if possible. The d-c blocking condensers *C1* and *C2* are matched button micas in order to maintain minimum equal inductance in these arms.

R1 is the balancing potentiometer. It should be a non-inductive unit to permit the bridge to function properly at radio frequencies. A suitable potentiometer for this use is the *Centralab Type M*.

R4 is the meter isolation resistor, and *X* is the crystal detector. A 1N23 crystal should be used for best sensitivity, but a 1N34 will serve satisfactorily as a less sensitive substitute.

The unit may be built in a *Bud Minibox*. If a 2-inch meter is used, a *Bud CU-3003* box (2¼ x 2¼ x 4 inches) will be the correct size. *National type FWH* terminal assemblies are used for the input and output connectors.

The assembly and wiring of the unit is very simple. *R1* is mounted on a small piece of bakelite or other phenolic board in the middle of a 1" hole drilled in the front of the box, thus insulating the case of *R1* from the box. One-quarter inch holes are drilled in the two center partitions to pass the leads from *R1* to the detector circuit. The juncture of *C1* and *X* are attached to an insulated tie strip at point A. All bridge leads should be kept as short as possible.

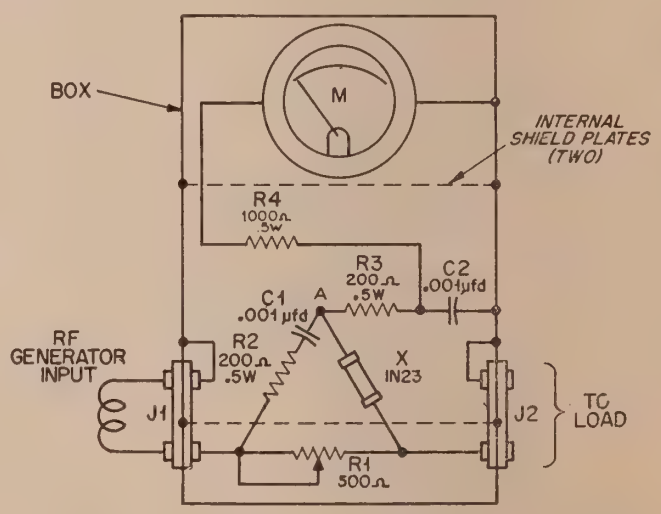
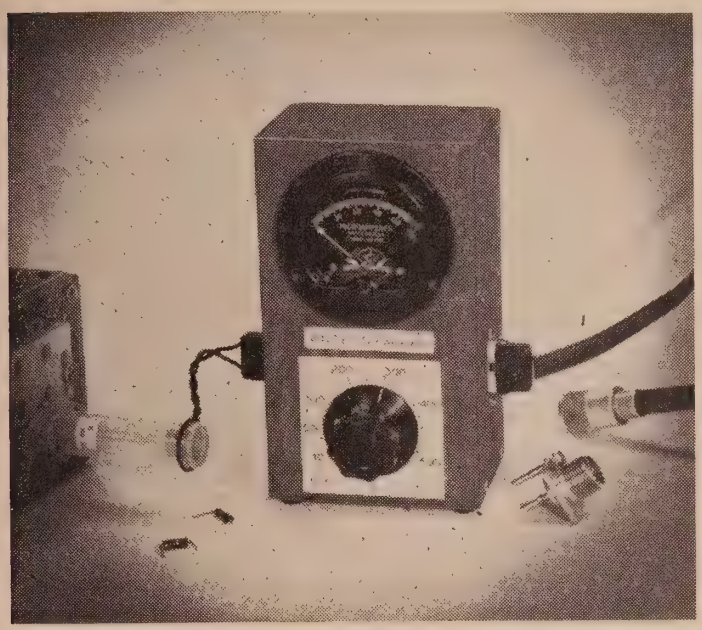


Fig. 7-2-A. Parts list and schematic for the Antennascope.

C1, C2—Matched 0.001 μfd. button micas.
R1—500-ohm potentiometer, Centralab type M.
R2, R3—200 ohms, ½w. see text.
R4—1000 ohms, ½w.
M—0-200 d.c. us., or less.
X—1N23 crystal diode.



The antennascope is an important addition to every Ham laboratory. It may be used to measure the resistive impedance of mobile antennas in the range of from 10 to 500 ohms.

Calibration

Calibration of the *Antennascope* is a simple process. First disconnect one of the leads from the potentiometer *R1*, and then connect an ohmmeter across its terminals. Mark the impedance scale at the desired points on the front panel according to the readings of *R1* obtained with the ohmmeter. Following calibration, the potentiometer should be reconnected.

The operation of the *Antennascope* may now be checked. At the input terminals connect a short length of twisted lead with a one-turn coupling loop at its end. The diameter of the loop should be such as to fit around the grid dipper coil. Set the dipper in the medium frequency range (5-30 Mc.). Slide the coupling loop over the dipper coil until approximately full scale reading is obtained on the *Antennascope*. Insert a 50-ohm ½-watt carbon resistor in the output terminals, and adjust *R1* for a null reading on the meter. The meter should drop to zero at a setting of 50 ohms on *R1*. The same test should be made for carbon resistors of other values, each time checking the calibration of *R1* against the value of the test resistor. The leads of the test resistors should be cut short and bent in such a manner so as to enable the resistor to be inserted directly into the output terminals.

At frequencies above 15 Mc., a one-turn coupling loop is usually sufficient for obtaining full meter readings. For lower frequencies, a two or three-turn loop will be required.

It must be kept in mind that a complete null is not obtainable unless the measured impedance is resistive, which, in the case of an antenna made up of inductive and capacitive reactances means it must be resonant at the frequency concerned. Incomplete nulls indicate the measured impedance is reactive.

Using the Antennascope with Mobile Antennas

The coaxial feed line should be disconnected from the base of the whip antenna, and the output terminals of the *Antennascope* connected between the whip and the frame of the car. The "hot" terminal of the *Antennascope* should connect to the whip, and the ground connection should connect to the frame of the car with a short lead. A suitable pickup coil should be connected to *J1*, and the *Antennascope* energized with a grid dipper. The frequency of the dipper and the setting of *R1* should be adjusted until a null is obtained on the meter of the *Antennascope*. The transmitting impedance of the antenna may then be read on the dial of the *Antennascope*, and the resonant frequency of the antenna may be determined from the frequency of the grid dip oscillator.

7.3—A Mobile Test Power Supply

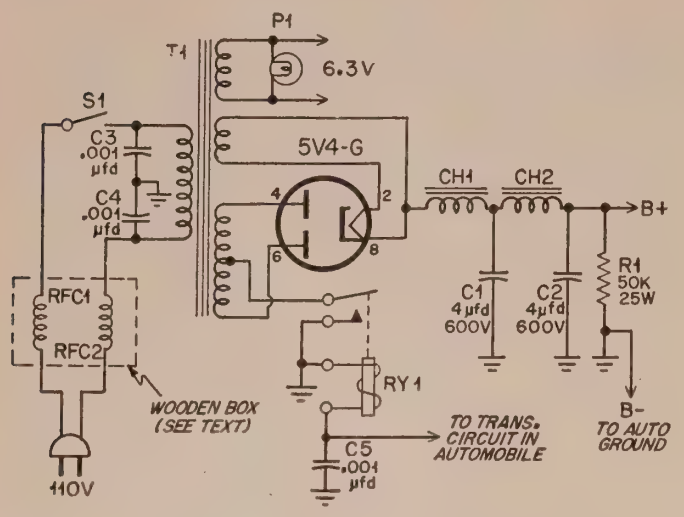
During testing and tune-up periods it is a great advantage to operate the mobile transmitter from 117 volts a-c, rather than from the 6-volt car battery. The a-c operated power supply described herewith is designed to take the place of the dynamotor or vibrator supply in the automobile during periods when testing is being done. This will save a great amount of wear and tear that would normally be inflicted on the car battery.

Care must be taken to make sure that the a-c operated test supply conforms in output voltage and current capacity to the dynamotor it replaces. The control circuits also must be so arranged that the test supply may be turned on and off by the usual transmitting switches and relays. This may be done by the addition of a 6-volt d-c relay to the supply. This relay, *Ry1*, makes and breaks the center tap of the high voltage supply. It is controlled by the "transmit" circuits in the car.

In addition, the a-c supply must not upset the antenna balance by adding extra capacity between the automobile and the ground. Suitable r-f isolation between the a-c line and the power supply must be provided for correct operation of the equipment.

A supply that meets these requirements is shown in *Fig. 7-3-A*. The transformer, *T1*, is chosen so as to provide a d-c output voltage of 300 or 400 volts. A two-section filter *(C1, C2, CH1, CH2)* is used to reduce the ripple to a suitable level for phone operation. The d-c output from the supply is controlled by relay *Ry1*. The high voltage output of the test supply may be connected directly to the transmitter high voltage connector by mean of a matching receptacle mounted on the test supply.

The transmitter filaments may either be run from the 6.3-volt winding of the power transformer, or may be left connected to the automobile battery and run from the automobile electrical system. Since the filament drain of



C1,C2—4.0 μfd., 600wv.
C3, C4, C5—0.001 μfd., ceramicon.
Ch1, Ch2—10 henries, 200 ma., UTC S-29.
P1—pilot light assembly, Johnson 147-500.
R1—50,000 ohms, 25 watts.
RFC1, RFC2—1.0 mh., amp., Miller 4534.
Ry1—S.p.d.t. relay, Advance 953B with 6-volt d-c coil.
T1—(300-volt, 150-ma output) use Stancor PC8411. (400-volt, 200-ma output) use UTC S40 or S43.

Fig. 7-3-A. Wiring schematic and parts list of the test bench mobile power supply.

a transmitter is small compared to the dynamotor drain, it will not hurt a well-charged battery to run the filaments of the transmitter for short testing periods.

RFC1 and *RFC2* are placed in the 117-volt line to the test supply. These chokes isolate the r-f circuits of the mobile transmitter from the a-c line. They should be mounted in a small wooden box and placed in the line cord a few feet from the supply, so that when the supply is placed in the automobile, the chokes will hang in the air, a few inches below the automobile. They should not be allowed to touch either the car or the ground.

While the cost of such a supply make make it uneconomical for a single mobile installation, it is a very worthwhile club project, where the cost of the supply may be divided among the members of the club.

7.4—The "Crystal Ball"

The "Crystal Ball" is a combination S-meter, carrier meter and modulation level indicator. A device such as this that will give an indication of whether or not the transmitter is on the air, if it is modulated and the degree of modulation can be of great value for mobile operation, where the dynamotor whine or a single plate meter may be the only means of monitoring transmissions. In addition, the *Crystal Ball* acts as a forward reading S-meter when the receiver is in operation.

The Basic S-Meter Circuit

A 0-150 microammeter acts as an indicator in a balanced bridge circuit, one leg of which is the plate resistance of an a-v-c controlled tube in the car receiver. The resistance values given with *Fig. 7-4-A* are typical, and may need to be varied if the particular receiver in use has a different plate voltage, if the no signal cathode voltage of the a-v-c tube is different, or if a meter of different sensitivity is used. If any one of these parameters is appreciably varied from those specified, the new values of the resistors may be calculated as follows:

1. Measure the a-v-c controlled tube cathode voltage *(Ek)* with no signal input to the receiver.
2. Measure the plate voltage *(Eb)* to which *R1* is connected.

$$R1 + \frac{R2}{2} = Eb \times 1000$$

$$R3 = Ek \times 1000$$

$$R4 + \frac{R5}{2} = \frac{Ek}{Im} \times 1000$$

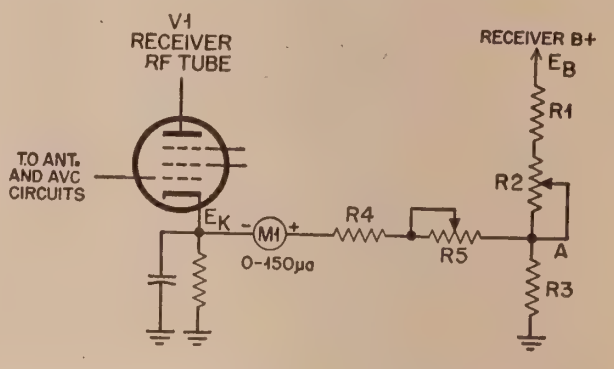
(*Im* is the full scale current reading of the meter in milliamperes)

The nearest standard resistor values may be used, and the results will be well within the range of adjustment of *R5*. As a rough check, *R5*, with half its resistance in the circuit should form from one-quarter to one-half of the total resistance of each leg.

3. With *R5* set at mid-scale, and no signal being received, adjust *R2* for zero reading on the meter. This occurs when the voltage at point *A* is the same as at *Ek*.
4. Now tune in an S9 signal. (You will have to decide what an S9 signal is!) Adjust *R5* until the meter reads at the point which you wish to call S9.

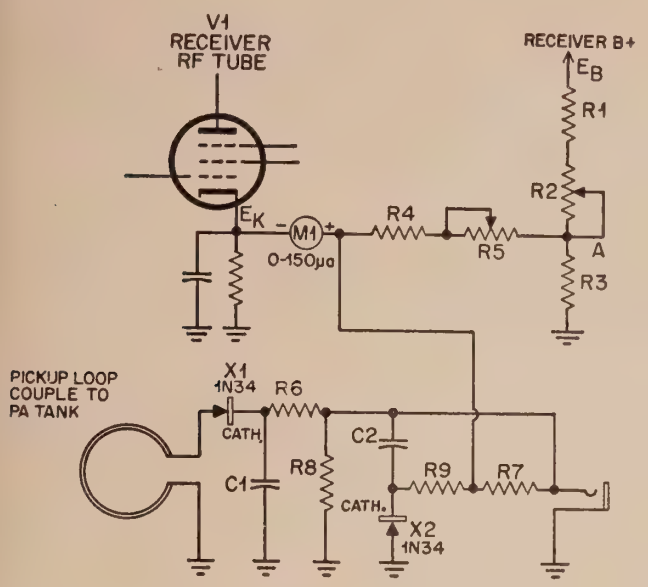
The Transmitter Monitoring Circuit

When transmitting the plate voltage is usu-



R1—150,000 ohm, ½w.
R2—100,000-ohm potentiometer, Centralab B-40.
R3—2000 ohm, ½w.
R4—5000 ohm, ½w.
R5—10,000-ohm potentiometer, Centralab B-14.

Fig. 7-4-A. The basic S-meter circuit.



C1—500 μμfd., Erie GP2K-501.
C2—0.05 μfd., 200wv., Sprague 2TM-S5.
J1—open circuit jack.
L1—one turn link near p-a tank coil.
M1—0-150 ua. d-c meter.
R1—150,000 ohm, ½w.
R2—100,000-ohm potentiometer, Centralab B-40.
R3—2000 ohm, ½w.
R4, R8—5000 ohm, ½w.
R5—10,000-ohm potentiometer, Centralab B-14.
R6—1000 ohm, ½w.
R7—82,000 ohm, ½w.
R9—10,000 ohm, ½w.
X1, X2—1N34 crystal diodes.

Fig. 7-4-B. Complete S-meter, carrier level and modulation indicator circuit for the "Crystal Ball" designed by W2CVV.

ally removed from the receiver and the S-meter reads zero, and is thus available for other functions. The addition of a pick-up loop, coupled to the transmitter output tank circuit and a crystal rectifier will allow the meter to indicate the relative output power of the transmitter. The complete circuit allowing these two separate functions to operate the meter independently of each other is shown in *Fig. 7-4-B*.

The S-meter circuit remains the same. R.f. from the transmitter tank is sampled by the pick-up loop and rectified by *X1*. The output of this portion of the circuit is d.c. varying in amplitude at an audio rate with modulation. *R6* is included to protect the crystal from possible overload and burn-out. It should be mounted near the crystal. A portion of the d-c output of *X1* is fed directly to the meter through *R7*. This will provide about ½ scale deflection of the meter from the carrier only, as an indication of carrier level. The remainder of the d.c. from *X1* is by-passed to ground by *R8*, but the audio components corresponding to modulation are rectified in *X2* and impressed on the meter through *R9*, causing it to swing from its carrier level toward full scale with modulation.

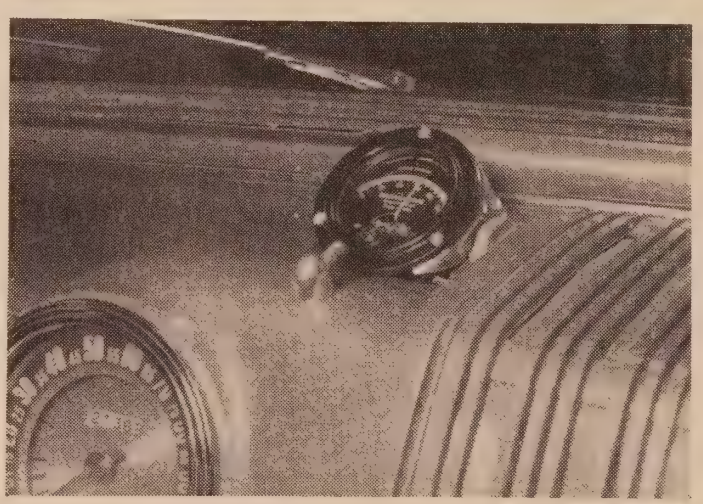
The constants shown in *Fig. 7-4-B* are intended to produce approximately ½ scale deflection of the meter from the carrier, provided the coupling loop is so adjusted as to produce five volts of d.c. across *R8*. The meter will swing just about full scale under 100% voice modulation. If it is desired to reduce the modulation sensitivity, increasing the value of *R9* will do it effectively. *R7* may be varied to control the carrier sensitivity.

A jack is included across the output of *X1*. Plugging a pair of earphones in it will permit checking modulation quality.

The pickup loop will have to be adjusted for each transmitter, but to give an idea of where to start, one turn about ½ inch from the "cold" end of the tank coil was found to be correct on both 4 Mc. and 29 Mc. with 40 watts input to the final amplifier.

Make all adjustments with the transmitter fully loaded, since both the tank current and crystal current go up with no-load operation.

Be sure the plate voltage is removed from the a-v-c controlled tube of the receiver and from the balancing network while transmitting, otherwise the S-meter current will be flowing through the meter during transmission monitoring periods.

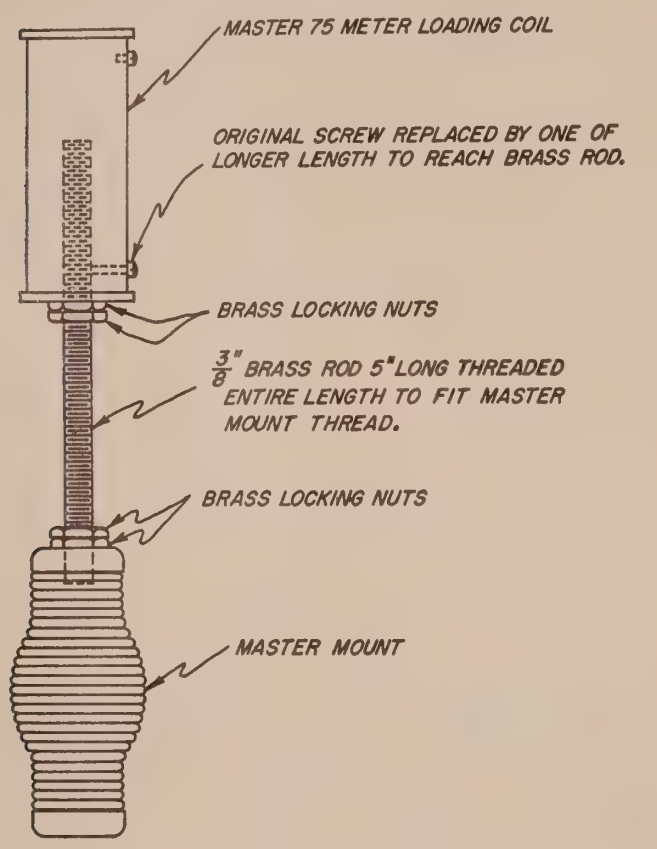


The "Crystal Ball" installed on the dashboard within easy view of the operator.

Mobile Antenna Ideas

Fine Tuning a 75-Meter Loading Coil

As with many of my brother Hams, I was interested in getting around in the 75-meter phone band and not being restricted to one frequency because of my mobile antenna. While sliding contact type inductances are nice I could not find one to serve my purpose. So I decided to "slug" tune the loading coil with a brass rod. The diagram shows how this was accomplished.


MASTER 75 METER LOADING COIL
ORIGINAL SCREW REPLACED BY ONE OF LONGER LENGTH TO REACH BRASS ROD.
BRASS LOCKING NUTS
3/8" BRASS ROD 5" LONG THREADED ENTIRE LENGTH TO FIT MASTER MOUNT THREAD.
BRASS LOCKING NUTS
MASTER MOUNT

The coil is pruned until the antenna resonates in the middle of the phone band (mobile portion) with the brass slug about half-way into the coil. The rod itself is 5-inches long and is threaded along its entire length. I used four nuts to keep it in place and also replaced one of the screws in the loading coil with one that was somewhat longer. This gives me considerable locking action.

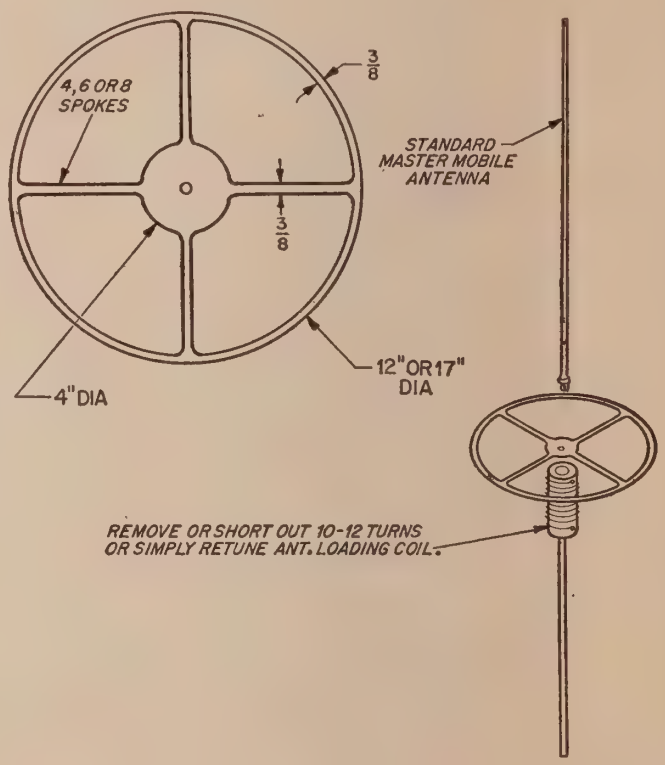
William A. Dennis, W1RFC

Mobile Antenna Capacity Ring

This capacity ring was easily made and at writing had been in use for over 6500 miles. The results while using the ring were very outstanding and my signal strength seems to have increased over three times that with the usual 75-meter center loaded vertical.

The ring is made from a standard 12-inch aluminum transcription disc. Either four or six "spokes" may be laid out with a compass and ruler by scratching in the necessary outline. A coping saw does the rest. I made my disc with the spokes and outer ring 3/8 inch in width. The center was 4 inches in diameter. There are no difficulties in mounting the ring since it may be secured to the top portion of the standard *Master Mount* mobile antenna as shown in the drawing.

After the ring is mounted it will be necessary to remove or short out 10 or 12 turns at either the top


4,6 OR 8 SPOKES
3/8
3/8
STANDARD MASTER MOBILE ANTENNA
12" OR 17" DIA
4" DIA
REMOVE OR SHORT OUT 10-12 TURNS OR SIMPLY RETUNE ANT. LOADING COIL.

or bottom of the loading coil. Don't forget to remove the shield and discard it. Paint the coil with a "poly" dope to further weather proof your installation. If you are really lucky and can obtain a 17-inch disc I believe you will find it increases the effectiveness of the antenna, but keep in mind that the larger the disc the less turns in the loading coil.

W. J. Karsten, W2LMH

(Continued from page 96)

10. Plug in the 12AX7 modulator. The resonance plate current should increase about 12 ma. when the 12AX7 has warmed up. The resonance plate current should now be about 65 ma.
11. Plug in the microphone and the 12AU7 speech amplifier tube. The resonance plate current should increase to about 80 ma. Upon speaking into the microphone, the plate current should kick to slightly over 100 ma.
12. Under the above conditions, the actual resonant plate current of the 5763 p-a tube will be about 40 ma., giving an input of 12 watts. The thermocouple meter in the antenna circuit should indicate about 0.5 ampere of antenna current, kicking up sharply under a sustained whistle. Do not leave the transmitter running with the microphone removed from *J1*, or let the transmitter run when the microphone button is not depressed. When the microphone is out of the circuit, the cathode return of the 12AU7 is broken, and the voltage across *C9* increases to about 80 volts. Also, it is possible for the 12AU7 to oscillate at some audio frequency. This effect causes no trouble in the automobile installation where the microphone switch breaks the plate power to the transmitter at the same time the 12AU7 cathode circuit is opened. It is merely mentioned, since it can happen when the microphone control circuit is not used.
13. The temporary leads may now be disconnected from the sub-chassis, and the cabinet prepared to receive the sub-chassis.

Final Assembly

Before the transmitter sub-chassis is put into the box, the microphone jack and the crystal holder should have 2-foot leads soldered to all terminals (including the ground terminal of the microphone jack), and they should be bolted into their respective mounting holes. The flexible coupling and extension shaft should be placed on the rotor of *C6*, and the leads from the front panel are threaded through the two remaining 3/16" holes in the chassis. The chassis is now inserted into the box and the four retaining bolts screwed into the bar stock through the matching holes in the box.

As a final step, the coaxial receptacle, *P2*, and the power receptacle, *P1* should be mounted on the box and wired.

Installation

The transmitter is mounted to the firewall of the automobile by means of four *8-32* screws passing through the corner holes of the case. The screws should make good electrical contact to both the firewall and the case.

For tune-up, a thermocouple r-f meter should be inserted at the base of the loaded whip antenna, and the coupling between *L1* and *L2* adjusted for maximum antenna current indication of the r-f meter. The plate current of the transmitter may be checked by a 0-100 ma. meter in the B plus lead to the transmitter. The resonant dip of the 5763 stage may be noted, and the total plate current drain of the transmitter held to about 80 ma. with no modulation. This amount of total current will allow 40 ma. to the 5763. The actual adjustments should be done with the idea in mind of obtaining a maximum reading of the r-f ammeter consistent with a total current drain of 80 ma.

A surplus antenna switching unit from the war surplus *Command* transmitters makes an excellent remote antenna meter. The thermocouple is removed and mounted at the base of the whip inside the car. The meter may be located near the transmitter so that it may be easily read.

Start with the number of turns indicated for *L2* in the *Coil Table*. If the total resonant plate current is over 80 ma., reduce the number of turns on *L2*, or push *L2* slightly away from *L1*. If the plate current to the transmitter is less than 80 ma., add turns to *L2*, or push it up the form slightly so that it overlaps *L1* slightly.

It should be understood that the loaded whip antenna should be resonant at the frequency at which these tests are being made. The remote r-f ammeter will *not* indicate the efficiency or tuning of the whip antenna. It merely indicates the relative amount of power that is being applied to the antenna in use. The radiation of this power depends entirely upon the efficiency and tuning of the antenna.

5.8—A Remote Co-ax Tuner for Receiver or VFO

The co-ax tuner is a simple and compact device whereby an oscillator may be tuned by remote control. For the mobile operator, it may be used in conjunction with a broad-band type of converter, or with one whose r-f circuits do not have a high degree of selectivity, wherein only the oscillator need be tuned. Its advantage for mobile use is that it permits the installation of the converter, or receiver, at some remote or inconspicuous place in the car, with tuning being done through the co-ax tuner at the most convenient operating position. It is completely portable and may be moved around at will, without affecting the operation of the receiver. The only connection required is a

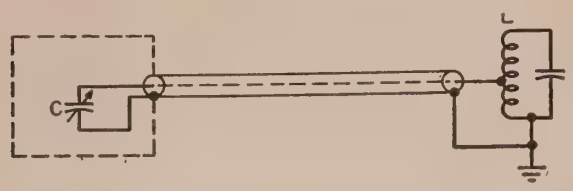


Fig. 5-8-A. Schematic of the remote tuner.

section of co-ax transmission line. It can also be used to tune a remotely located v-f-o controlled transmitter, where retuning of the final amplifier is not needed to maintain efficiency over the desired frequency range.

Figure 5-8-A is the circuit diagram of the remote co-ax tuner, which, in itself, consists only of the variable capacitor, *C*, mounted in a small metal box. The capacitor is tapped across a portion of the frequency determining circuit, of the oscillator, through the co-ax line. The tuning effect is the same as if the capacitor were connected as shown in *Fig. 5-8-B*.

Although almost any length of line may be used, precautions must be taken to avoid certain critical lengths, since transmission lines have reactive characteristics which depend upon the electrical length of the line. As the capacitance of *C* is increased, the effective electrical length of the line is also increased, and with certain initial line lengths, the reactance, as seen from the oscillator end of the line, will become inductive rather than remain capacitive, and the resonant frequency of the oscillator tank will then be raised instead of lowered. This will depend upon both the initial electrical length of the line and the maximum value of the variable capacitor. The shift in the direction of the frequency change will not be a smooth transition, but it will be evidenced by a sudden frequency jump, at one point, to a frequency quite a bit higher.

The best line length is usually a half wave, or a multiple thereof, at the highest frequency to be employed in the oscillator range. Shorter lengths may be used, but some cut and try procedures may be required to arrive at a length where the frequency varies in the same direction over the entire range of the capacitor.

The point at which the line is tapped on the oscillator inductor will depend on the amount of bandspread desired, and on the ratio of the tuning capacitance to that of the line reactance, together with that of the other oscillator capacitances expressed across *L*. *C* should be a fairly large size, since, for a given bandspread, the line must be tapped higher up on *L* as the maximum value of *C* is lowered. This would then require tapping over a large section, or even all, of *L*, and the oscillator will then cease to function, because the low impedance of the line is now placed across too great a portion of the circuit.

The tuning capacitor should be one which produces the desired degree of bandspread, while the line is tapped over as little a section of *L* as possible, and it should be one which will not lengthen the line by an amount which will reverse the direction of the frequency change

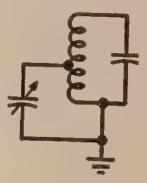


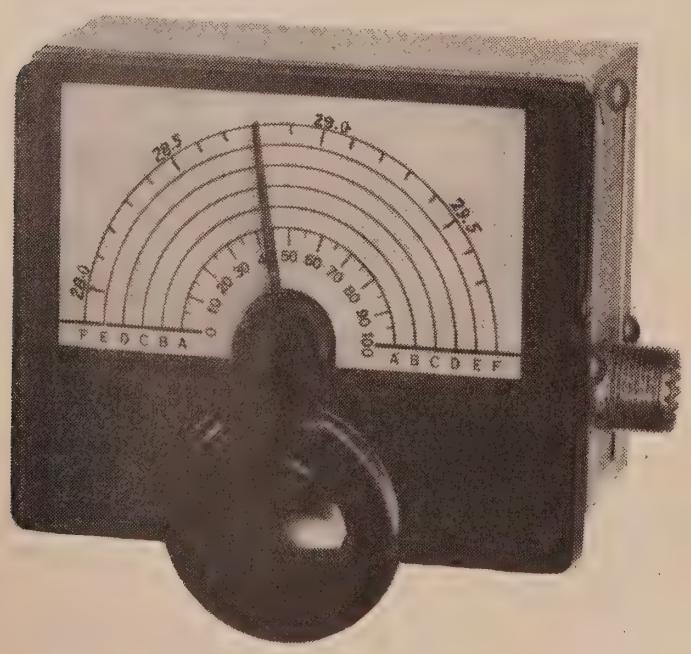
Fig. 5-8-B. Equivalent tuning effect of the remote unit.

when used with a given length of line. Here again, some experimentation may be required. In general, maximum values for *C* of 100 $\mu\mu$fd. will be satisfactory for 28 and 14 Mc., with somewhat higher values for lower frequency use.

A fairly uniform degree of bandspread may be obtained when using a half-wave line and a tuning capacitor having a straight-line capacitance curve. At shorter line lengths the bandspread may tend to compress at the high frequency end of the range, in which case a capacitor with a straight-line frequency curve will be better.

No special requisites must be met in the construction of the tuner, except that the variable capacitor should be one of good mechanical construction for the maintenance of oscillator stability. The unit shown here was used to tune a broadband 28-Mc receiver, and consisted of a 100 $\mu\mu$fd. variable capacitor mounted in a 1" x 3" x 2" aluminum box. The latter was made by cutting down a 5" x 4" x 3" *Bud Minibox*, so that the over-all size was made as small as possible while still permitting mounting of the *Millen #10039* vernier dial, together with the capacitor.

No extra ground connection is required at the remote co-ax tuner. It is recommended that RG-59/U coaxial cable, which is fairly flexible, be used for the line connecting the tuner to the oscillator.



The remote tuner is mounted in a cut-down Bud Minibox. The only connection is a length of 75-ohm co-ax cable which is plugged into the fitting shown on the right side.

Front panel view of the 60-watt mobile transmitter modified from a design in the May 1953 issue of CQ Magazine.

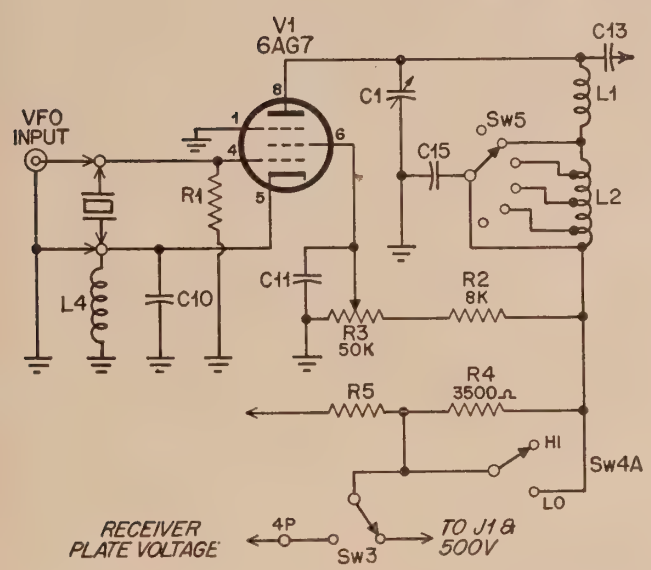


Fig. 5-9-A. This crystal oscillator replaces the circuit shown in Fig. 1, page 45, May 1953 issue of CQ. Additional circuit changes consist of raising R6 to 28,000 ohms, lowering R8 to 29,000 ohms and making RFC1 an R-300-U choke (2.5 mh.).

5.9—A High Powered Version of the W4SIA Transmitter

This is a brief description of a modified design of the 30-watt, 5-band mobile transmitter described by Earl Ferguson, OX3BI/W4SIA in the May, 1953 issue of *CQ Magazine*. This transmitter may be operated at inputs up to 60 watts phone and 75 watts CW, depending upon the available d-c plate power.

Since the original transmitter was fully described in *CQ*, only the differences in the two circuits will be discussed. Reference should be made to the original article, copies of which may be obtained by sending 50c to the Circulation Dept. of the magazine.

In the r-f portion of the transmitter a 6AG7 is used in a tri-tet circuit in place of the original 6AQ5 *(Fig. 5-9-A)*. This results in slightly more grid drive to the p-a stage with less crystal current than possible with the 6AQ5. Over

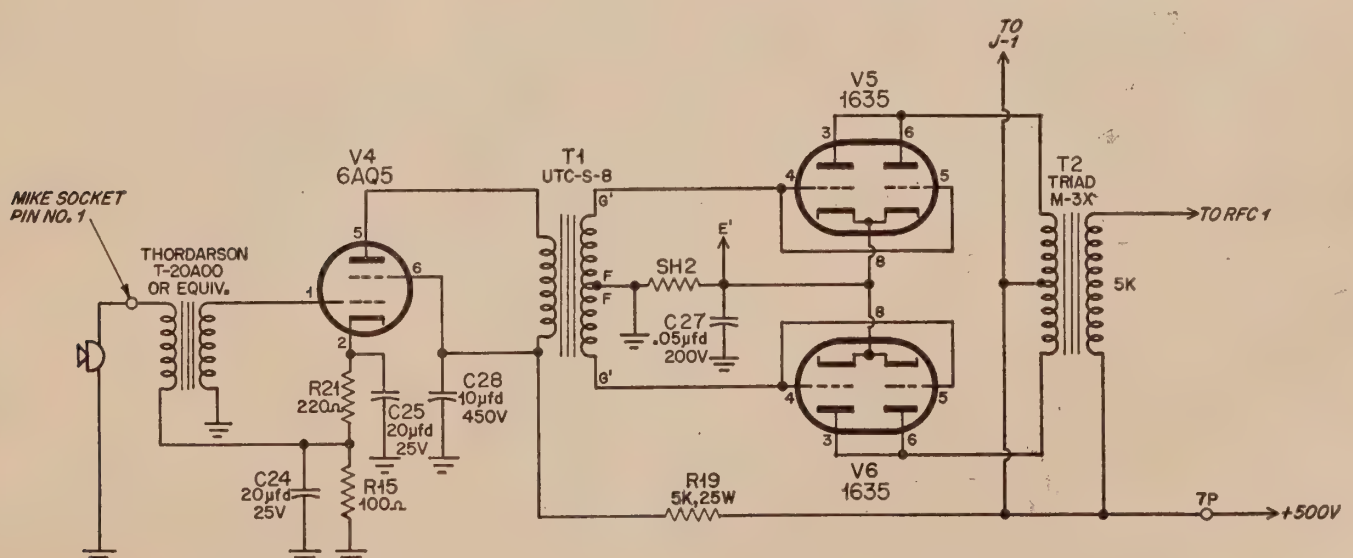


Fig. 5-9-B. This modulator provides 30 watts of audio and replaces the original design using a single 1635 tube.

Filament wiring arrangement in the modified circuit.

4 ma. of grid current is obtained on 28 Mc. when quadrupling from a 7-Mc crystal.

Because of the greater height of the 6146, the vertical sub-chassis is moved about ¼" to the left to allow enough room for the tube to be removed from its socket without disturbing the plate coil. Note that a slightly different oscillator plate and screen supply circuit is used and that the values of the 6146 grid and screen resistors are different from those in the original 30-watt transmitter. The plate choke, *RFC1*, of the 6146 now must handle 150 ma. and *National R-300U* is recommended.

The modulator portion of the transmitter is redesigned to provide an output of 30 watts. The two 1635 tubes are parallel connected as shown in *Fig. 5-9-B*. If desired, they may be cross-connected so that the modulator will operate with one tube removed. This will reduce the modulator resting current by 13 ma. when operating on reduced power.

The new and larger modulation transformer should be a *Stancor A-3845* and must be sub-mounted about ⅜" below the chassis in order to clear the case. However, the *Triad M-3X* transformer has the same ratings but is of slightly smaller shape and will mount on top of the chassis.

A three section electrolytic is used for *C24/25/28*. A *Cornell-Dublier UP-2145C* may be used.

Note that the meter shunts *Sh-1* and *Sh-2* should be rewound to give a 200 ma. full scale reading on the meter. For the meter described in the article *(Triplett 221-T,* O-10 ma.), the shunts are 17 inches of #30 magnet wire wound on a high value 1-watt resistor.

The front panel of the modified transmitter was finished by first drilling shallow holes to mark the positions of the controls and then filling these holes with India ink. Decals were then cut and placed in the correct positions, the panel having first been sprayed with one coat of *Krylon* acrylic spray. After the decals dried, the panel was given six more coats of *Krylon*.

5.10—75-Meter VFO Transmitter

This transmitter, designed and built by W1JNM, is a 15-watt v-f-o transmitter, covering the 3.8-4.0-Mc phone band. It consists of a small v.f.o. that is designed to mount under the dashboard of an automobile *(Fig. 5-10-A),* and a remote power amplifier and modulator unit *Fig. 5-10-B)* that is located in the rear trunk compartment. The transmitter has remotely controlled antenna tuning, and may be completely operated from the driver's position in the car. Plate input is 15 watts to the final amplifier.

The v.f.o. *(Fig. 5-10-C)* uses a 6AU6 tube as an e.c.o., with the grid circuit tuned to 160 meters. The plate circuit of the oscillator is broadly tuned to 75 meters by slug tuned coil, *L2*. A 6AK6 buffer stage follows the oscillator, the plate circuit of the 6AK6 also being tuned to 75 meters by the *L3-C12* tuned circuit.

The 6AK6 output stage of the v.f.o. is coupled by a length of RG-59/U coaxial cable

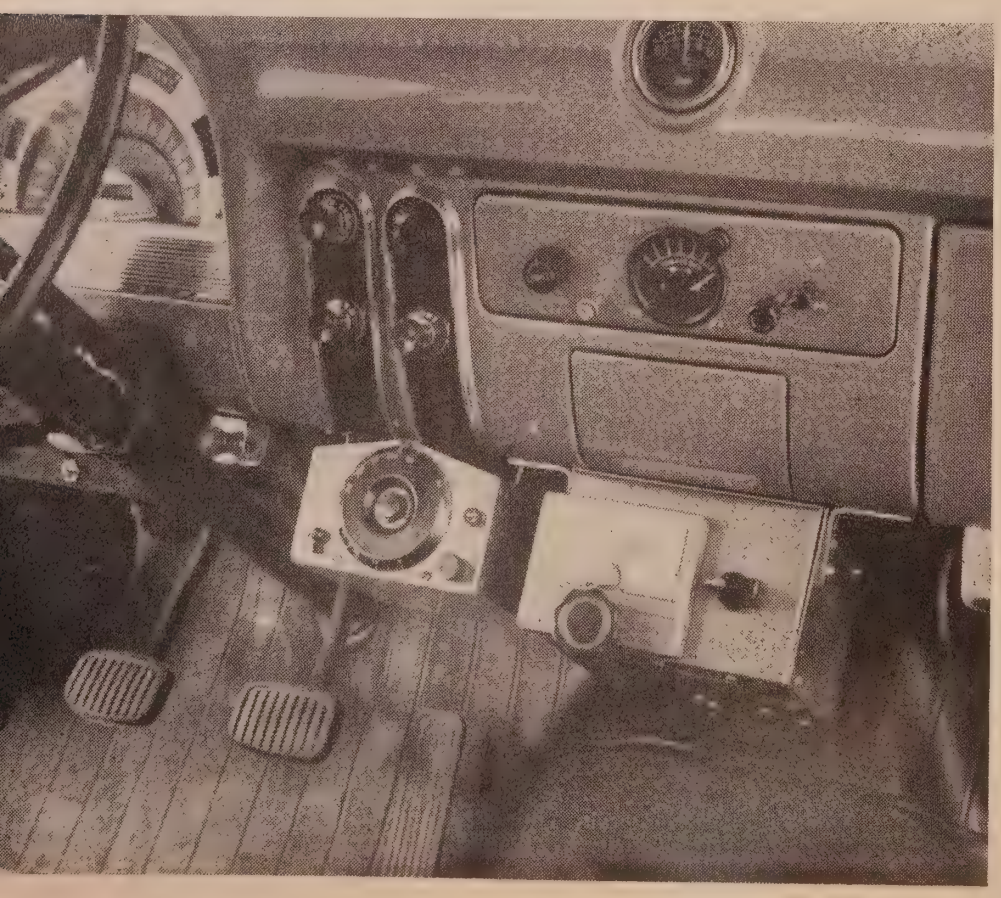


Fig. 5-10-A. This is the installation at W1JNM of a 75-meter v.f.o. It is mounted just to the right of the steering column with the receiving converter directly under the center of the dash. This center panel contains the crank and meter for remote antenna tuning.

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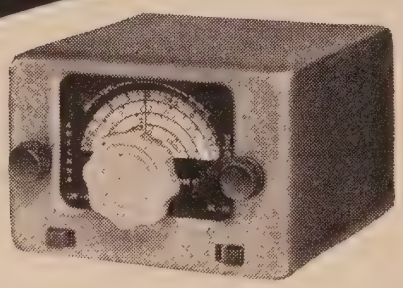

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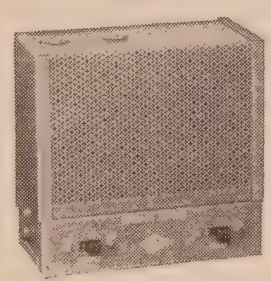

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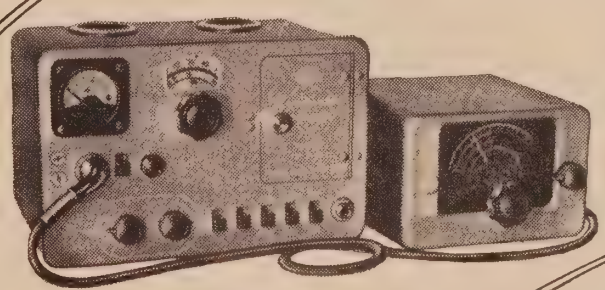

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to the grid circuit of the 2E26 final amplifier stage, *Fig. 5-10-D.* The grid circuit of the 2E26 *L4-C14,* is broadly resonant in the 75-meter band. The 2E26 plate circuit is coupled to the antenna by a method to be described later.

A 1635 tube is used as a class B modulator for the 2E26, and a single parallel connected 6N7 is used as a speech amplifier. The audio input circuit is designed for any single button carbon microphone, the button current being taken from the automobile 6-volt supply through a hash filter, *R12-C30.*

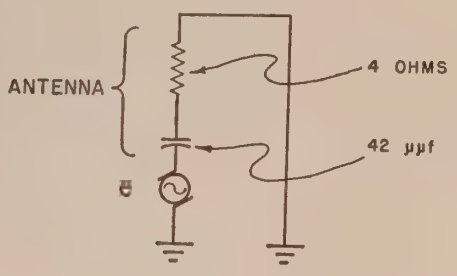


Fig. 5-10-E. This is the electrical analogy of a 9-foot antenna without loading in the 75-meter phone band.

A 1N34 crystal diode *(X1)* coupled to the output tank circuit is used to operate an antenna tuning meter *(M3)* located on the dash of the automobile.

The power for the v.f.o. is obtained from the receiver, and the transmitter may be powered by a vibrator supply or a dynamotor capable of delivering 300 volts d-c at 150 milliamperes.

The Antenna Coupling System

A 9-foot unloaded whip at 3.9 Mc. is electrically equivalent to 42 μμfd. condenser in series with a 4 ohm resistor *(Fig. 5-10-E).* To obtain the equivalent of 50 watts in the antenna, a current of 3.55 amperes must flow through the resistor and condenser. The condenser has a known reactance of 970 ohms at 3.9 Mc., so the equivalent voltage at the base of the whip must

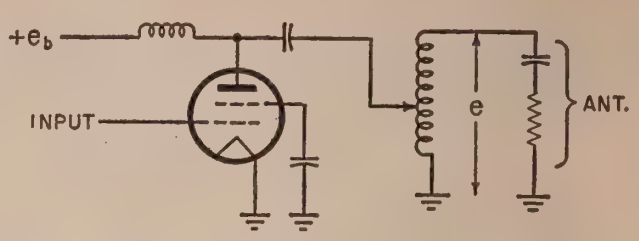


Fig. 5-10-F. The high Q of the 75-meter antenna will permit matching to the transmitter through a tapped coil arrangement.

be 3.55 x 970, or 3450 volts r.m.s.

A load such as this may be matched to a transmitter by placing a coil in parallel with the load, as shown in *Fig. 5-10-F.* The tap on the coil may be made adjustable in order to control the coupling to the antenna. For simplicity and efficiency, the coil may be broken into sections, as shown in *Fig. 5-10-G.* The total inductance to tune from 3800 to 4000 kc.

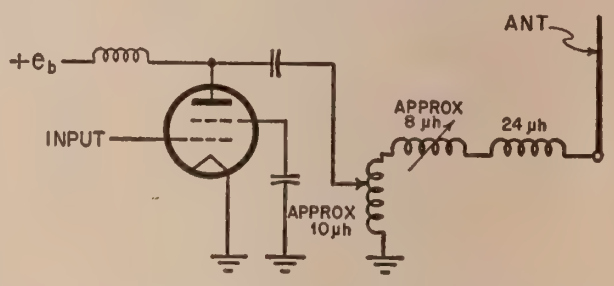


Fig. 5-10-G. The tapped coil shown in the basic schematic of Fig. 5-10-F may be broken into sections for convenience and simplicity. The variable inductance will tune over the 3800 to 400 kc. range.

must be adjustable from about 38 μh to 42 μh. Also, the bottom coil of the inductance must have an adjustable tap to control transmitter loading. This coil should be about 10 μh. A variable inductance having a range of about 2 to 8 μh. should follow this, and the remaining inductance of approximately 24 μh. should be placed in the center of the whip, in the form of a center loading coil.

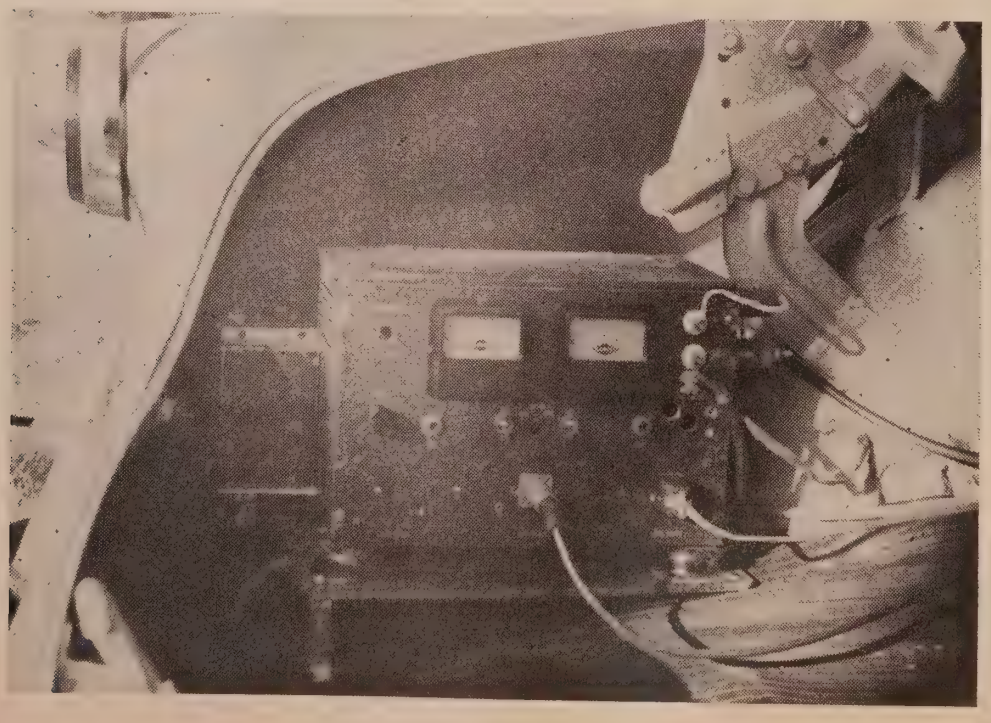
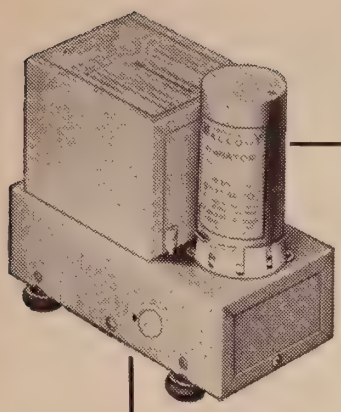


Fig. 5-10-B. The transmitter of the W1JNM mobile is located in the trunk compartment. The antenna tuning and loading variometer are fastened to the cabinet at the left.



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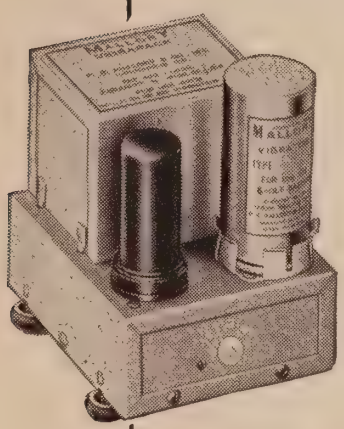

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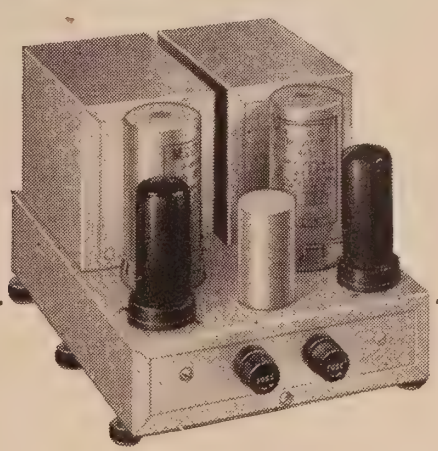

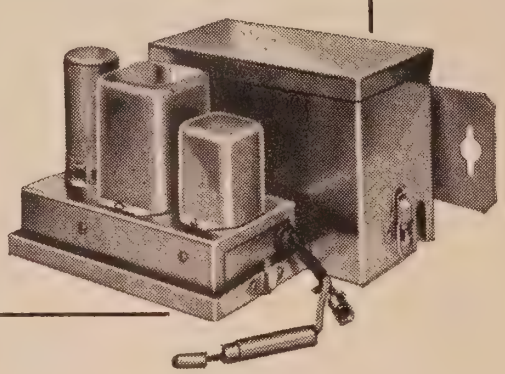

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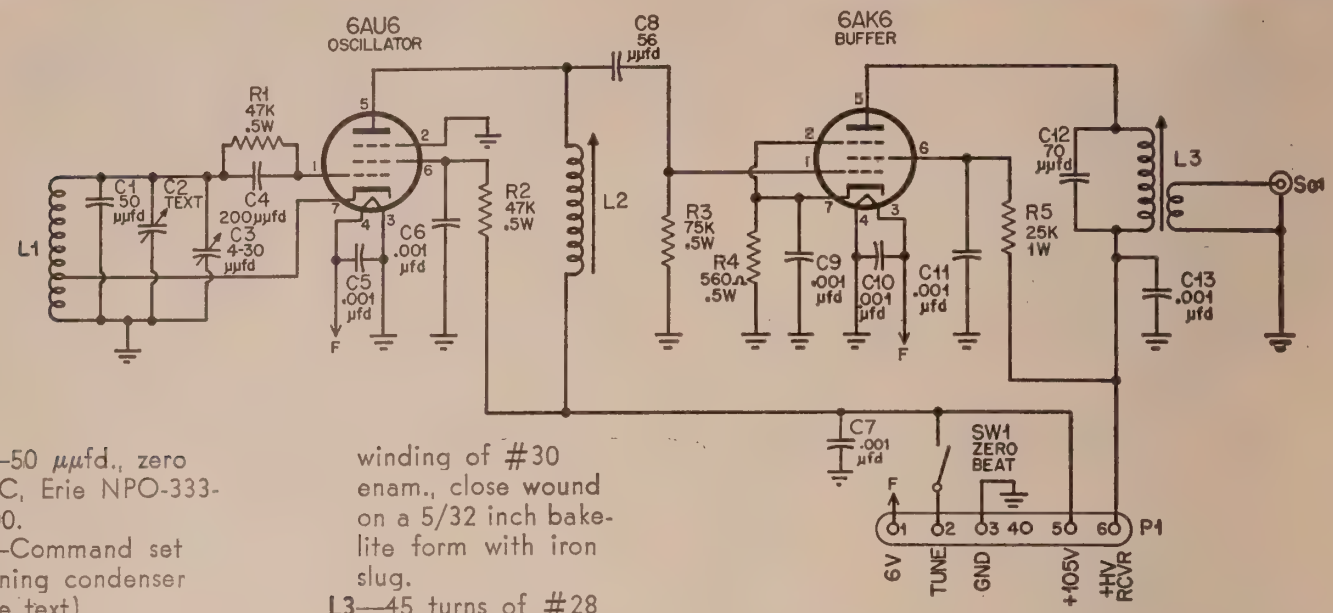

C1—50 μμfd., zero T-C, Erie NPO-333-500.
C2—Command set tuning condenser (see text).
C3—4-30 μμfd., variable, Erie TS2A-4.
C4—200 μμfd., ceramic, zero T-C, Centralab TCZ-200.
C5, C6, C7, C9, C10, C11, C13—0.001 μfd., Centralab DD-102.
C8—56 μμfd., ceramic.
C12—70 μμfd., ceramic.
L1—44 turns, #28 enam., close wound, tapped 15 turns from ground end on Amphenol No. 24 form.
L2—J. W. Miller adjustable choke #4563, or 1½ inch winding of #30 enam., close wound on a 5/32 inch bakelite form with iron slug.
L3—45 turns of #28 DSC on National XR-50 form. Link consists of 6 turns #28 DSC wound over the B plus end of L3. Cement in place with coil dope.
P1—receptacle, Jones S-306-FP.
P2—plug, Jones S-306-CCT.
R1, R2—47,000 ohms, ½w.
R3—75,000 ohm, ½w.
R4—560 ohm, ½w.
R5—25,000 ohm, 1w.
So1—receptacle, ICA-2378 and plug, ICA-2375.
Sw1—S.p.s.t. toggle.

Fig. 5-10-C. Parts list and wiring schematic of the W1JNM v.f.o unit.

The actual antenna installation used by W1JNM consists of a 7-foot top section, and an 8-inch "top-hat" capacity, a 1½" diameter loading coil having 80 turns of #18e., spaced to a length of 6 inches, and a lower rod section 2½' long. The antenna is attached to the rear bumper of the car by an insulated mount. This antenna, if grounded at the feed point, will resonate at 4150 kilocycles.

The antenna lead passes through the car body via a ceramic insulator, and is connected to the variometer, *L6,* located inside the car body. The addition of the variometer will alter the antenna resonant frequency to give a range of 3750 to 4050 kc. The antenna loading is practically constant when the antenna is tuned throughout the 75-meter band.

The particular variometer used is a surplus item, and may not be easily duplicated. A *Johnson 229-201* rotary inductor, having a maximum inductance of 10 μh will make an excellent substitute.

The antenna is coupled to the transmitter by means of *L5,* an inductance common to both the antenna circuit and the plate circuit of the final amplifier. To compensate for this added inductance, a fixed series condenser, *C20,* is added in series with *L5.* This condenser has equal and opposite reactance to *L5,* and maintains the frequency range previously obtained by the use of the variometer.

Each of these units of the antenna circuit should be of excellent quality in order that the *Q* of the circuit be maintained as high as possible. All connections should be of low resistance and well soldered.

The coupling coil, *L5,* has 3 adjustable taps. The antenna tap *(A)* is adjusted slightly to set the antenna tuning range for 3750 to 4050 kc. When set, this tap may be soldered. The p-a plate loading tap *(B)* should be adjusted for a 2E26 plate current of 55 ma. at resonance. Plate loading will *decrease* as the p-a tap is moved *up* the coil *away* from the grounded end. Tap *(C)* is used to match the receiver coaxial line to the antenna network, and should be adjusted for best receiver sensitivity. The variometer or rotary inductance used for *L6* is remotely tuned as described in *Chapter 6.3,* using flexible shafting to connect the inductor to a remote crank located in the operating position. This crank is shown in *Fig. 5-10-A.*

Parts from a Command receiver control head are used to make a gear box and crank to turn the flexible shaft. At the inductor end of the shaft a worm drive from a BC-375 tuning unit is used to provide a smooth, vernier action *(Fig. 5-10-H).*

Construction Details of the VFO

The v.f.o. *(Fig. 5-10-C)* is constructed upon the chassis of a BC-457 Command transmitter, the panel of which was cut off just above the tuning dial *Fig. 5-10-I).* The old p-a condenser is used for *C2,* the v-f-o tuning condenser. A

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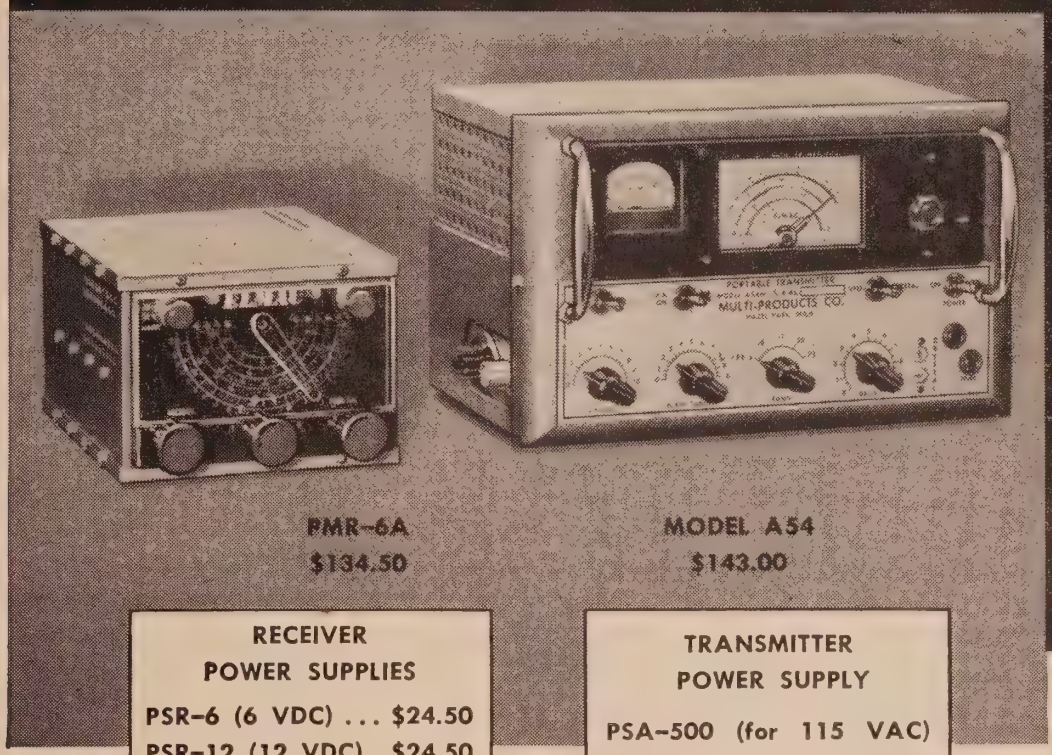

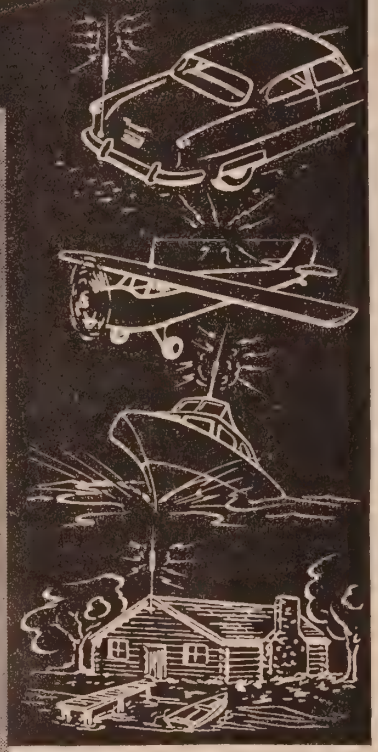

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PSR-6 (6 VDC) . . . $24.50
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section of the chassis is cut out and the rear section is moved forward to meet the front section, making the chassis 6 inches deep, over-all. All components are mounted inside the chassis which serves as the case for the v.f.o. A small rectangular aluminum plate is used as a sub-chassis inside the case, and is mounted in an inverted position. It is secured to the case top by 8-32 screws and ⅝" metal spacers. All the components of the 6AU6 and 6AK6 stages, with the exception of *C2* mount on this sub-chassis. All the small components go on the "top" of the sub-chassis, and the two tubes, and *L1, L2* and *L3* mount "upside down" on the "bottom." A bottom view of the v.f.o. is shown in *Fig. 5-10-H*.

A rectangular hole is cut in the top of the case to make the v-f-o wiring accessible for testing purposes without having to remove the sub-chassis from the case. This opening is covered by the mounting bracket of the v.f.o.

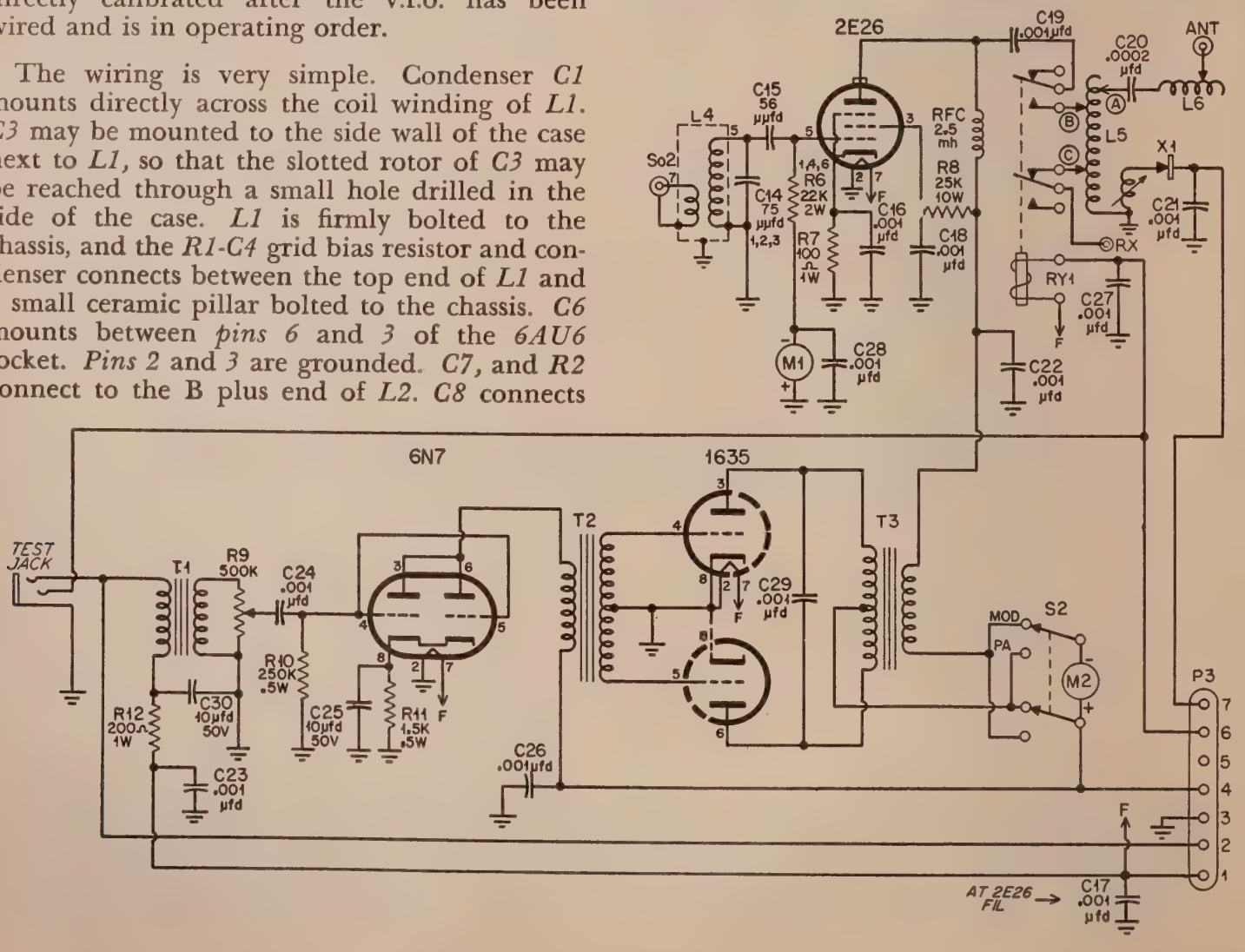
The power plug, *P1,* is mounted on the rear of the chassis in the original power receptacle hole. The v-f-o zero-beating switch, *S1,* is mounted at the lower left of the front panel, and is switch #6540 from a Command set control head. It is used as a single-pole normally open switch.

The original dial markings on the v.f.o. should be painted out and a paper scale may be made to fit over the old scale. This new scale may be directly calibrated after the v.f.o. has been wired and is in operating order.

The wiring is very simple. Condenser *C1* mounts directly across the coil winding of *L1*. *C3* may be mounted to the side wall of the case next to *L1,* so that the slotted rotor of *C3* may be reached through a small hole drilled in the side of the case. *L1* is firmly bolted to the chassis, and the *R1-C4* grid bias resistor and condenser connects between the top end of *L1* and a small ceramic pillar bolted to the chassis. *C6* mounts between *pins 6* and *3* of the *6AU6* socket. *Pins 2* and *3* are grounded. *C7,* and *R2* connect to the B plus end of *L2*. *C8* connects

Fig. 5-10-D. Parts list and wiring schematic of the power amplifier and modulator used by WIJNM.

C14—75 μμfd., ceramic, Erie NPO-333-750.
C15—56 μμfd., ceramic, Erie GP1K-560.
C16, C17, C18, C21, C22, C23, C24, C26, C27, C28—0.001 μfd., Centralab DD-102.
C19, C29—0.001 μfd., ceramic, 1000v., Erie 1R5KV-102.
C20—0.0002 μfd., 2000v., Sprague 8FM-32.
C25, C30—10 μfd., 50v., Mallory TC-32.
M1—0-10 ma., d-c meter.
M2—0-200 ma., d-c meter.
P3—(same as P1)
P4—(same as P2)
R6—22,000 ohm, 2w.
R7—100 ohm, 1w.
R8—25,000 ohm, 10w.
R9—500,000-ohm potentiometer, Centralab B-59.
R10—250,000 ohm, ½w.
R11—1500 ohm, ½w.
R12—200 ohm, 1w.
RFC1—2½ mh., National R-100U.
Ry1—D.p.d.t., relay, Advance series 2000 with 6-volt coil.
So2—(same as So1)
Sw2—D.p.d.t. toggle.
T1—microphone transformer, Merit A-2923.
T2—Driver transformer, Merit A-2922.
T3—10-watt modulation, Merit A-3008.
L4—Use Millen 74001 coil form. Wind 38 turns of #28 DSC. Link is 6 turns #28 DSC wound around ground end of coil. Adjust coupling between winding for proper grid drive to 2E26 then cement windings in place.
L5—15 turns, 2½ inches diameter and about 1⅝ inch long, or preferably B&W #3906-1 inductor.
L6—Johnson 229-201 rotary inductor.



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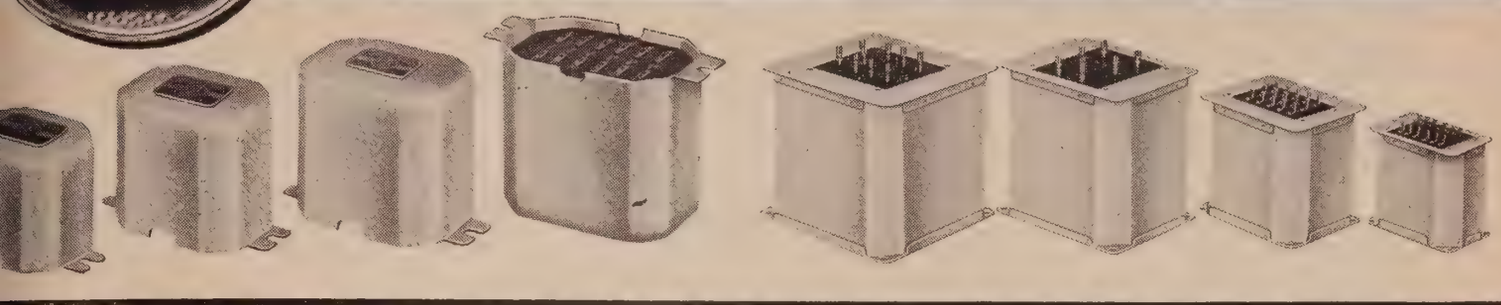

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o.	Application	Ratio	Net Price
	1 plate* to 2 grids	2:1 4:1	$4.50
	Single or double button mike or line to 1 grid hum-bucking type	16:1	4.70
	Single or double button mike or line to 1 grid, compact type	16:1	3.50

UNIVERSAL DRIVER TRANSFORMERS

o.	Application	Net Price
	Pushpull driver plates to grids of class B tubes up to 400 watts output	$6.00
	Pushpull 56, 6C6 triode, 6C5, or similar plates to 45's, 2A3's or 6L6's, self of fixed bias.	5.50

NIVERSAL MODULATION TRANSFORMERS

Secondary carries class C current
Any modulator tubes to any RF load.

lo.	Audio Power	Net Price
	12 watts	$ 6.00
	30 watts	9.00
	55 watts	13.00
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Primary Impedance	Typical Tubes	Net Price
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2500 ohms	2A3, 6A3, 6A5, 6B4, 6L6, 6Y6, 25L6, 35L6	
4000 ohms	31, 43, 45, 48, 6V6, 12A5, 12A6	$5.20
7000 ohms	33, 47, 42, 47, 59, 89, 2A5, 6AC5, 6F6, 6K6, 6N6, 7B5	
10.000 ohms	37, 38, 41, 1G5, 3C5, 6A4, 6N7	
P. P. Tubes:		
4000 ohms	6Y6, 25L6,	
5000 ohms	45, 2A3, 6A3, 6A5, 6B4	5.50
10,000 ohms	30, 1H4, 6AC5G, 6B5, 19, 49, 53, 79, 89, 6A6, 6N6, 6N7, 6Y7	
3000 ohms	45, 48, 2A3, 6A3, 6A5, 6B4, 25L6	
6000 ohms	42, 2A5, 6F6 triodes	
	46, 59, Parallel 53, 6A6, 6N7	7.00
9000/10000 ohms	42, 45, 2A5, 6AC5, 6B5, 6F6, 6L6, 6V6	
3800 ohms	6L6's	
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Type No.	Voltage	D.C. Voltages*	Rectifier Fil.	Fil. No. 1	Fil. No. 2	Net Price
S-40	525-425-0- 425-525 250 Ma.	400/310	5 V.-3A	6.3 V.C.T. -3A	6.3 V.C.T. 3A	$15.00
S-41	600-0-600 200 Ma.	475	5 V.-3A	7.5 V. tapped 6.3 V.-3A	6.3 V.C.T. 2A	15.00

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Type No.	High Voltage	DC Voltages*	DC Current	Net Price
S-47	1500-1250-1000-0- 1000-1250-1500	1275/1050/825	300 Ma.	$23.00
S-48	1500-1250-1000-0- 1000-1250-1500	1300/1075/850	500 Ma.	34.00
S-49	2100-1800-1500-0- 1500-1800-2100	1815/1540/1275	300 Ma.	33.00
S-50	3000-2500-0-2500 3000	2625/2175	300 Ma.	50.00

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S-53	2.5 VCT	10 A.	1500 V.	$3.70
S-54	5 VCT	4 A.	2500 V.	3.70
S-55	6.3 VCT	3 A.	1500 V.	3.70
S-57	2.5 VCT	10 A.	10,000 V.	5.50
S-59	5 to 5.25 VCT	13 A.	5000 V.	5.50
S-62	10 VCT	10 A.	3000 V.	6.50

No.	Fil. 1	Fil. 2	Fil. 3	Insulation	
S-65	2.5 VCT-5A	5 VCT-4A	6.3 VCT-3A	3000 V.	6.50
S-67	5 VCT-6A	6.3 VCT-5A		3000 V.	6.50
S-70	6.3 VCT-5A	6.3 VCT-5A		3000 V.	7.00

FILTER AND SWINGING CHOKES

Type No.	Service	Inductance	Current	Resistance	Insulation	Net Price
S-26	Filter	15 Hy.	60 Ma.	230 ohms	1500 V.	$ 3.50
S-27	Filter	30 Hy.	75 Ma.	350 ohms	1500 V.	4.50
S-28	Filter	20 Hy.	100 Ma.	350 ohms	1500 V.	4.50
S-29	Filter	10 Hy.	175 Ma.	95 ohms	1500 V.	4.50
S-31	Filter	20 Hy.	225 Ma.	120 ohms	2700 V.	6.00
S-32	Swinging	5/25 Hy.	225 Ma.	120 ohms	2700 V.	6.00
S-33	Filter	20 Hy.	300 Ma.	90 ohms	4000 V.	8.50
S-34	Swinging	5/25 Hy.	300 Ma.	90 ohms	4000 V.	8.50
S-37	Filter	20 Hy.	550 Ma.	60 ohms	6000 V.	16.00
S-38	Swinging	5/25 Hy.	550 Ma.	60 ohms	6000 V.	16.00

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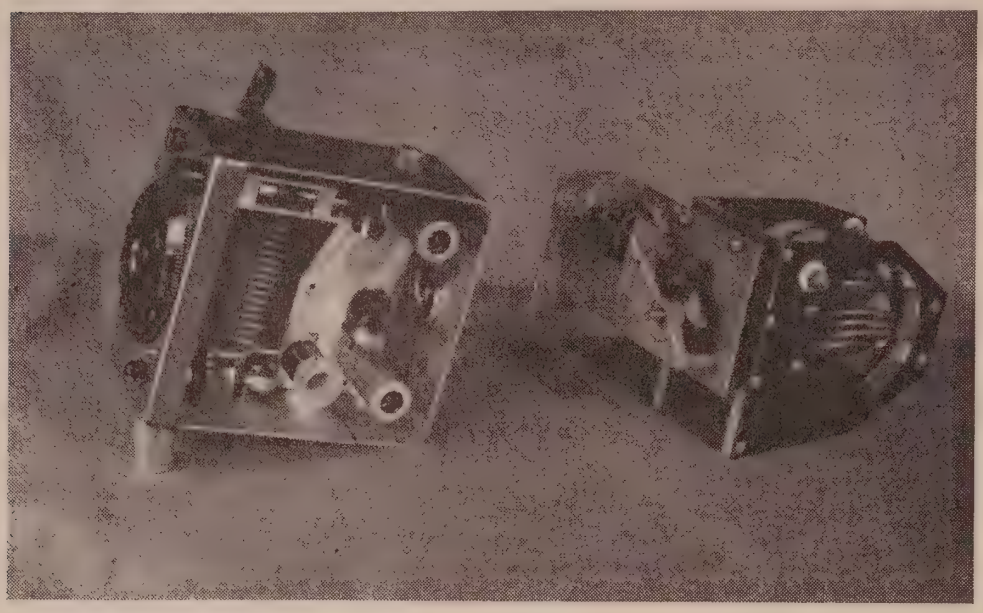

Fig. 5-10-H. Bottom view of the v.f.o. and variometer. The latter is a war surplus unit with a drive from the BC-375 transmitter. When installed the gears are completely covered.

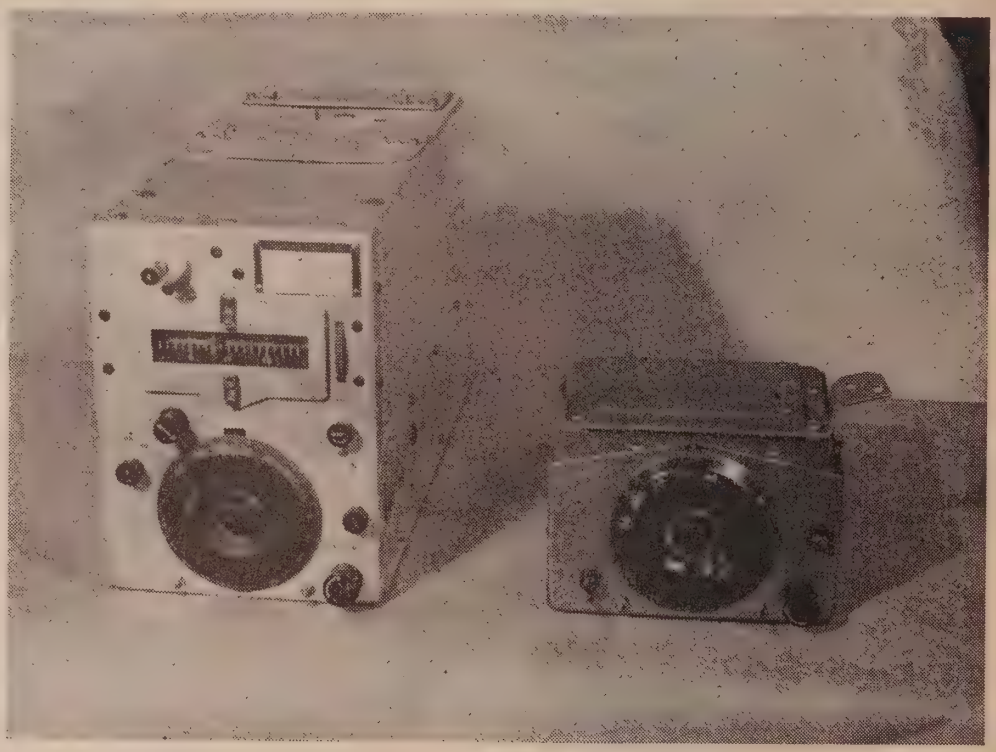

Fig. 5-10-I. The v-f-o chassis is cut down from a BC-457 Command transmitter. The bracket on the top of the v.f.o. is bent to conform to the dashboard of the automobile. It is made of steel and the entire v.f.o. has been sprayed to match the interior color of the W1JNM '53 Ford. See text for additional details.

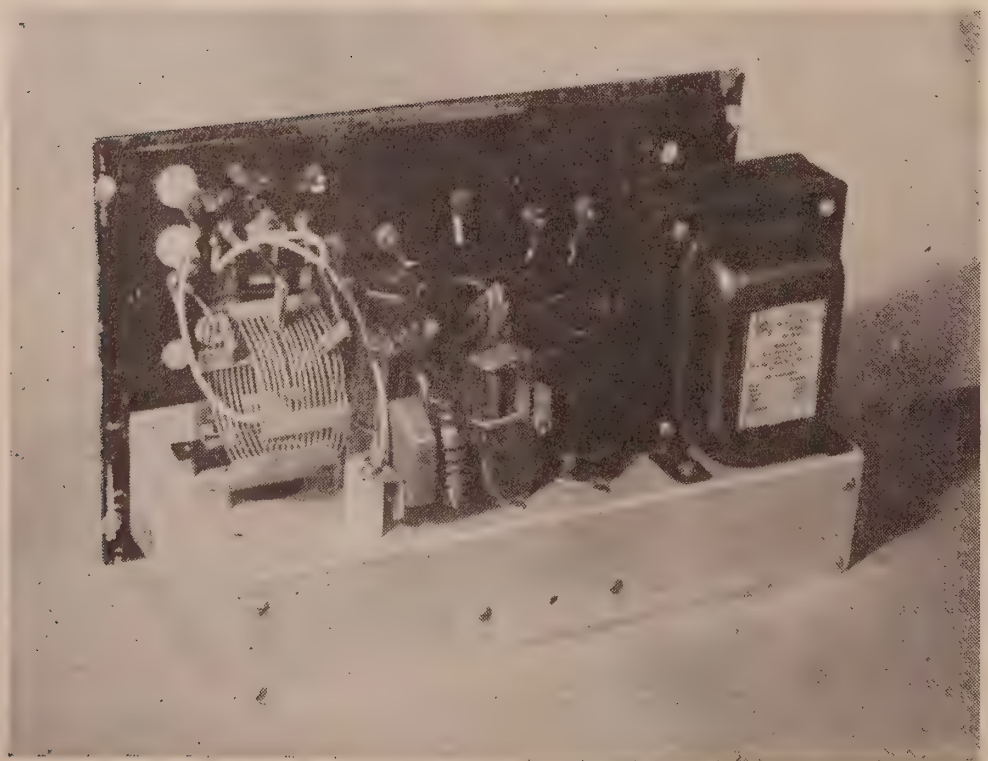

Fig. 5-10-J. View of the W1JNM transmitter chassis. The oversize modulation transformer is not the one mentioned in the text and was the result of some experiments. The coil at the left is the coupling coil L5 with the taps plainly visible.

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from *L2* to *pin 1* of the 6AK6 tube. *Pin 3* of the 6AK6 is grounded, and *C9, C10,* and *C11* are bypassed to this pin. *C12* is connected across the winding of *L3*.

Construction Details of the Transmitter

The transmitter may be built on a *Bud CB-996* chassis (5½ x 9 x 1½) which will fit the *Bud C-993* cabinet (7 x 8 x 10), making a compact and neat package. The variable inductor and worm drive are bolted on the outside of the cabinet. Two 2-inch square meters (*M1* and *M2*) are mounted on the panel of the unit, as is the test jack for an auxiliary microphone. The gain control, meter switch, power plug, and receiving antenna fitting are also mounted on the front panel of the transmitter.

Coil *L4* is wound on a shielded *Millen 74001* coil form. The link winding of *L4* should be cemented in place once the correct amount of coupling has been set.

Relay *Ry1* is the "antenna" relay and should have ceramic insulation. It is mounted on the panel of the transmitter, directly in front of *L5*.

Coil *L5* is cut from a section of *B&W Inductor #3906-1,* and is mounted on two ceramic standoff insulators. *L7,* the pickup link, is loosely coupled to the ground end of *L5*. The position of *L7* is adjusted to give a usable reading on the remote tuning meter.

In wiring the transmitter, *C14* is connected directly across the socket prongs of *L4*. *Pin 7* of the 2E26 is grounded. *C16* connects between *pins 1, 4,* and *7*. *C18* connects between *pins 3* and *7*. *RFC1* is a *National R-100U* base mounting choke, and *C22* connects between the bottom of this choke and ground. *C20* is mounted on the inside wall of the cabinet, and a ceramic feed-thru insulator carries the output lead from *C20* through the cabinet wall to the variable inductor mounted on the outside wall of the cabinet.

The modulator wiring is straightforward and simple. Mount all parts as close to their respective sockets as possible and keep all audio grid leads short.

The Power Supply

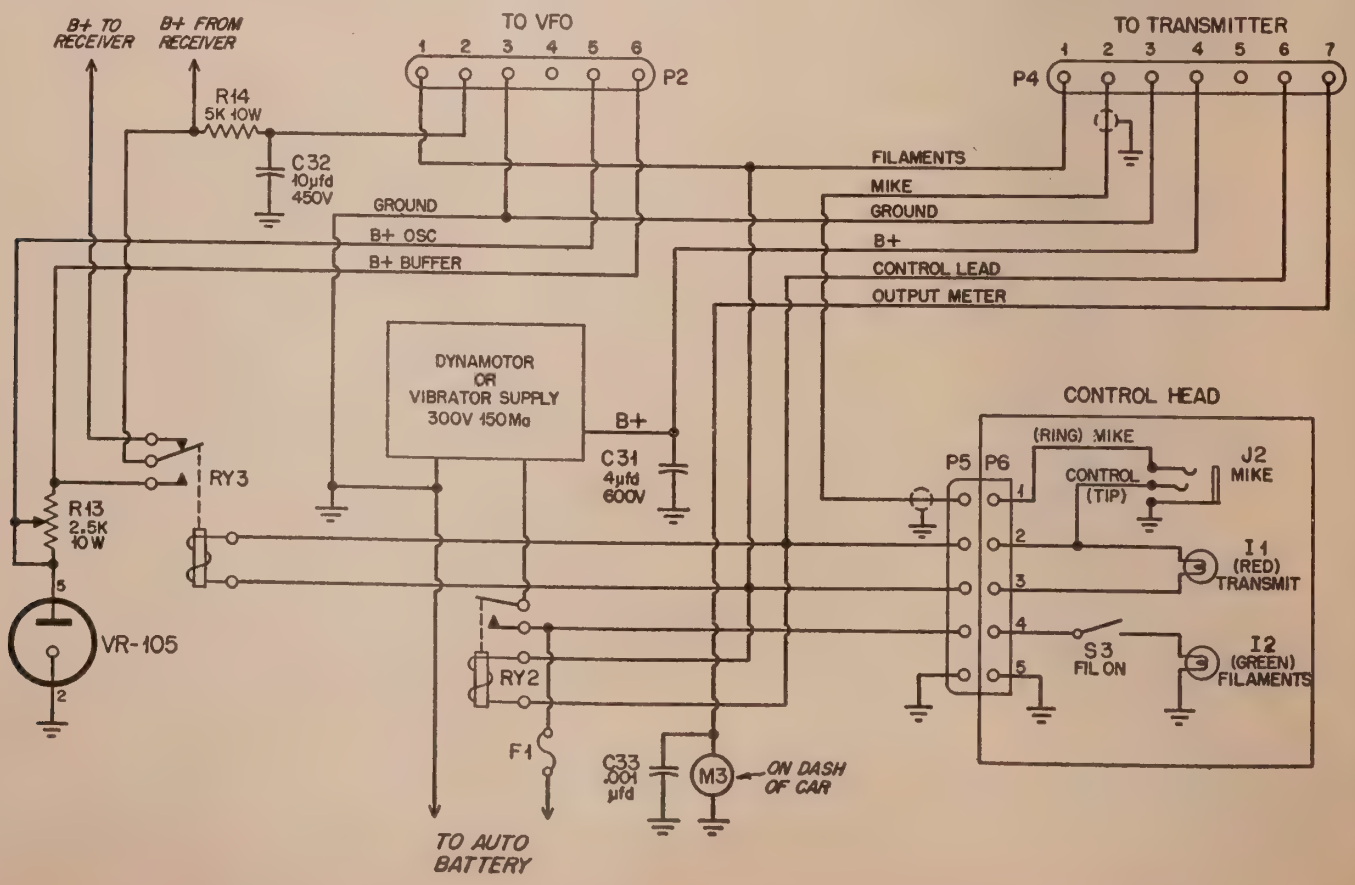
The power for the v.f.o. is obtained from the automobile receiver, as shown in *Fig. 5-10-L*. The receiver has a VR-105 tube incorporated in its circuit to stabilize the oscillator voltage on the transmitter. Relay *Ry3,* the VR-105, *R13, R14* and *C32* should all be mounted on a small plate near the receiver. *R13* may have to be changed in value from that specified, depending upon the value of the voltage taken from the receiver.

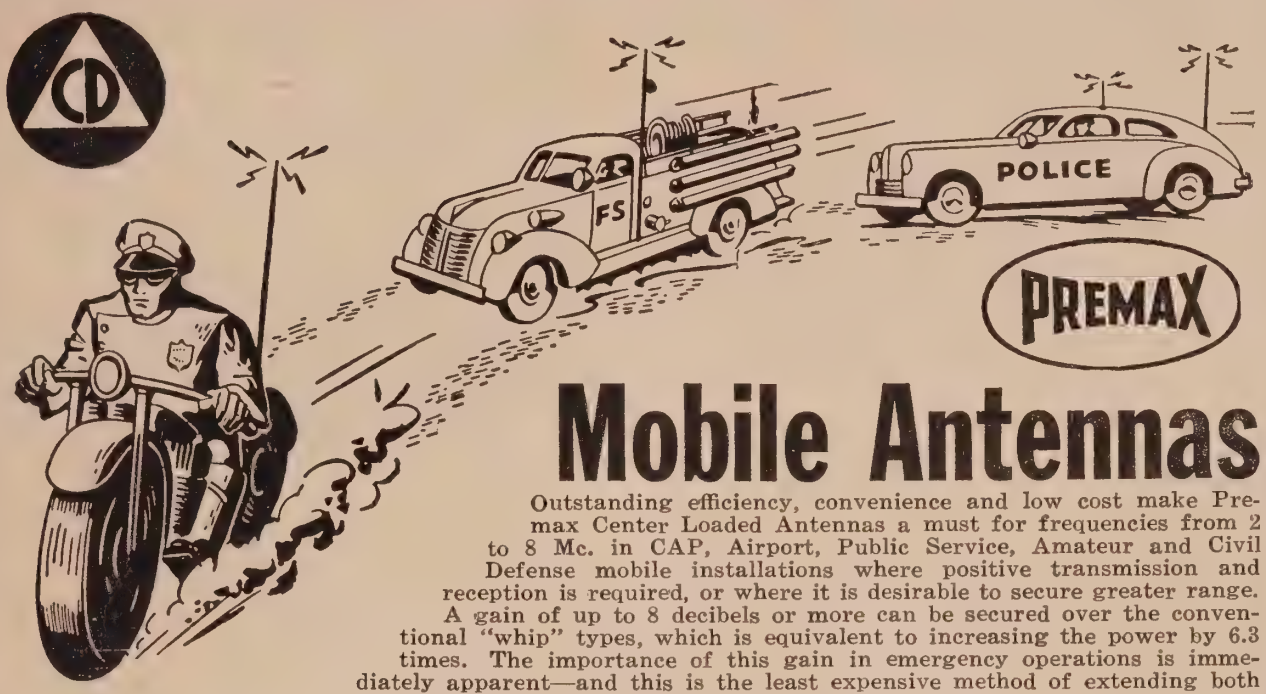
Initial Tune-up

All units should be interconnected and turned on. The filament voltages at *P1* and *P3* should be checked for correct values. *C3* should be set for correct oscillator coverage of 1900 to 2000

Fig. 5-10-K. Control wiring of the W1JNM mobile.

C31—4 μfd., 600wv., C.D. KR-604.
C32—10 μfd., 450v., Sprague TVA-1705.
C33—0.001 μfd., Centralab DD-102.
I1, I2—Lamp assembly, Dialco #27.
J2—3 circuit jack, ICA #1922.
P2—see v.f.o. parts list.
P4—see power amplifier parts list.
P5, P6—(same as P1, P2)
R13—2500 ohms, adjustable, 10w.
R14—5000 ohms, 10w.
Ry2—Relay, Advance 951C with 6-volt coil.
Ry3—Relay, Advance 946B with 6-volt coil.





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The Series B Antenna consists of a 6-foot tapered whip mounted above a loading coil and a 2-foot base road with couplings to fit any Premax or other standard mounting. The coil is wound on specially treated hardwood core and waterproofed after winding. Can be used for multi-band CD or amateur operation by shorting out turns on the coil. Available in either regular (BXS) or spring (BSS) type, for 20 meter, 75 meter, 2000 to 3000 kc. marine, 3105 kc. airport and 2374, 4325 and 4585 kc. CAP.

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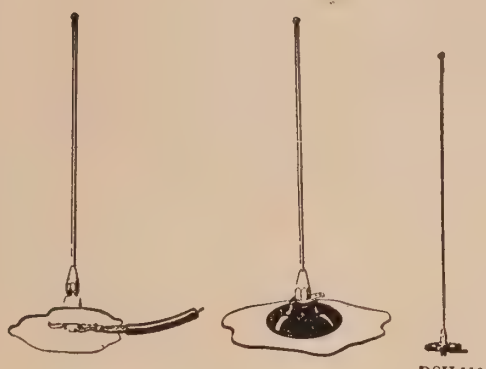

CD-11 CD-21 DSH-118

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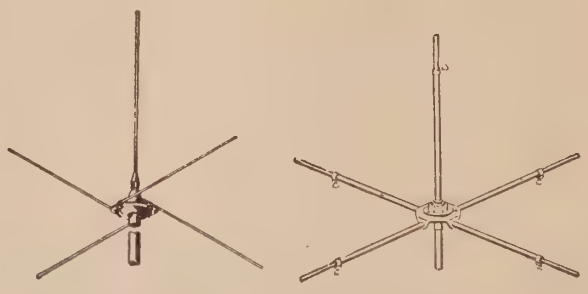
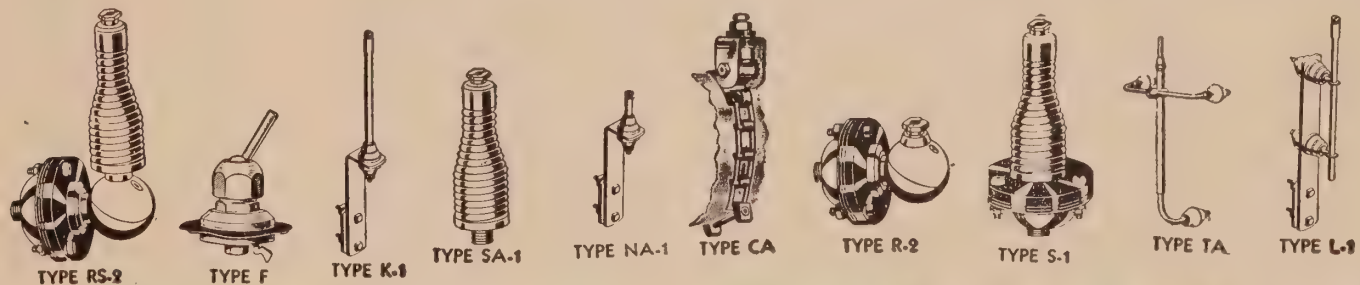


GP-314 GP-430

GROUND PLANE ANTENNAS

GP-430 has adjustable tubular aluminum elements for 20-40 or 40-60 meters. An exceptionally light-weight unit with waterproof cable connector housing. Fits ½" threaded pipe. No. GP-314 has non-adjustable spring steel elements for 108-120 mc., 144 mc. or 152-162 mc.



TYPE RS-2 TYPE F TYPE K-1 TYPE SA-1 TYPE NA-1 TYPE CA TYPE R-2 TYPE S-1 TYPE TA TYPE L-1

MOBILE MOUNTINGS

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kc. *L2* should be tuned with a grid dipper to 3.9 Mc. *L3* should be also tuned to 3.9 Mc. by the grid dipper.

A temporary power supply, such as described in *Chapter 7.3* should be attached to the transmitter, and the slug of *L4* adjusted for a grid current reading on *M1*. The coupling between *L4* and the link coil should be adjusted for a grid current of 4 ma. The feed-thru insulator from *C20* to the variable inductor should be temporarily shorted to ground, and reduced plate voltage applied to the 2E26. *Ry1* should be closed, and tap *A* on *L5* adjusted for resonance of the output circuit. When this is obtained, a lamp bulb may be coupled to *L5* for a temporary check out procedure.

When the r-f unit is working, a microphone should be plugged in the test jack on the panel, and the operation of the modulator checked. Under 100% modulation, *M2* should kick to about 60 or 70 ma., from a resting current of 12 ma.

When the unit operates properly, *C20* should be unshorted and the equipment placed in the automobile. The transmitter should be attached to the whip antenna and turned on. The variable inductor may then be tuned by the remote control cable until an indication of loading appears on *M2*. Tap *B* of *L5* is then adjusted for correct loading, and tap *C* for best reception. Since the antenna is part of the tank circuit, the remote meter connected to link *L7* will indicate a maximum reading when the antenna circuit is "tuned on the nose." It is best to operate the 2E26 at a reduced plate and screen voltage until the transmitter and antenna have been initially tuned up.

Operation

1. The transmitter filaments are turned on by *S3*.
2. The transmitter is placed on the air by pressing the microphone control button.
3. The transmitter is set on frequency either by the calibrated v-f-o dial, or by zero-beating an incoming signal.
4. The transmitter is put on the air and the remotely tuned loading coil, *L6*, is tuned for maximum reading of the tuning indicator. This is the only meter needed for operating purposes.

5.11—A 300 Watt Mobile Transmitter

This 300-watt mobile transmitter was built by Ray Thomas, W6BHH. It is designed to operate from a fanbelt driven BD-77 dynamotor supplying 1250 volts to the final r-f amplifier and modulator. Power for the speech driver and r-f exciter unit is obtained from a dual-vibrator supply or small dynamotor capable of supplying 400 volts at 150 ma.

Figure 5-11-A shows the complete transmitter mounted in the turtle-back trunk compartment of a 1951 *Chevrolet*. The transmitter is only 10″ x 17″ x 9″ in size, complete. It actually takes up much less room in the automobile than many transmitters running considerably less power input.

Electrical Design

A 7C5 tube serves as a crystal oscillator on 80 and 40 meters, and as a crystal oscillator doubler for 20, 15 and 10 meters. Thus only 80-meter and 40-meter crystals are used for coverage of all bands.

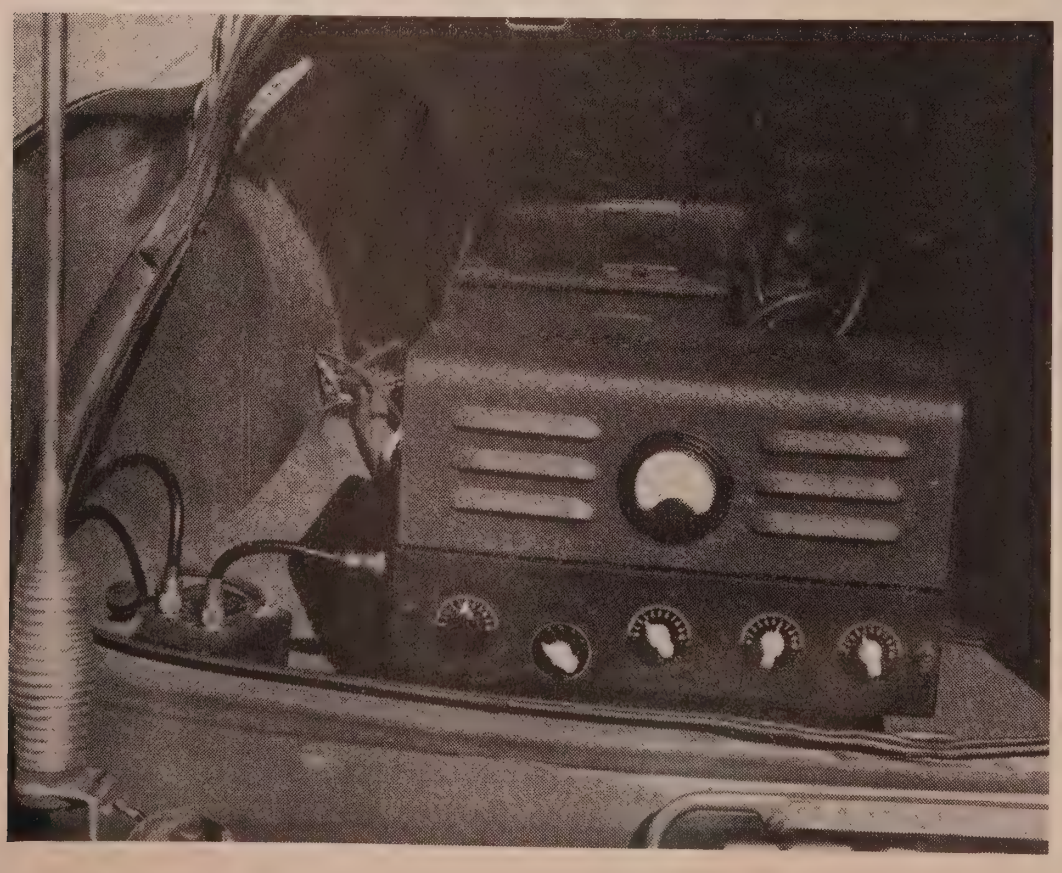

Fig. 5-11-A. This is the complete 300-watt transmitter designed by W6BHH. The auxiliary PE-103A dynamotor is mounted directly behind the transmitter.

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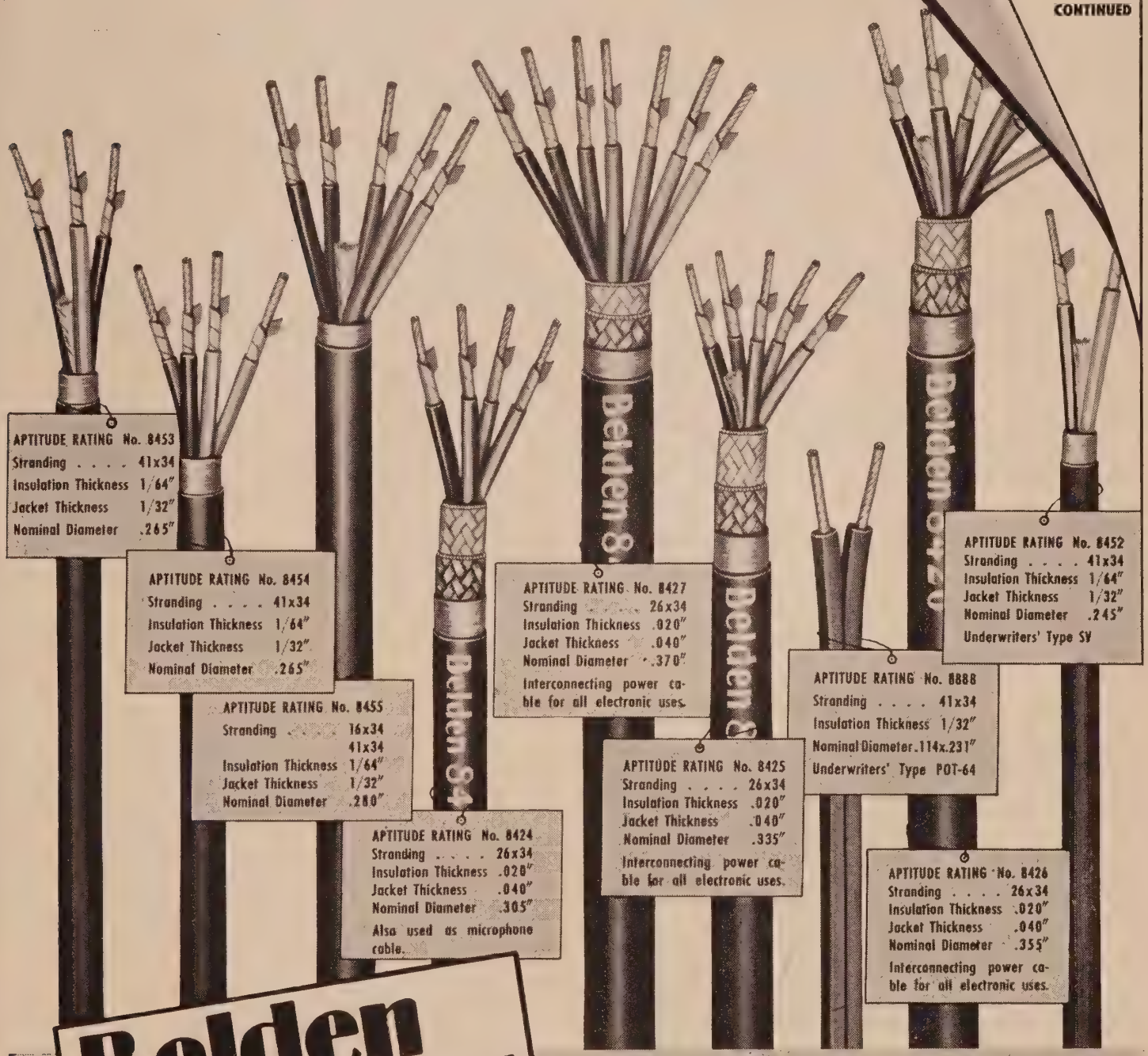

APTITUDE RATING No. 8453
Stranding 41x34
Insulation Thickness 1/64"
Jacket Thickness 1/32"
Nominal Diameter .265"

APTITUDE RATING No. 8454
Stranding 41x34
Insulation Thickness 1/64"
Jacket Thickness 1/32"
Nominal Diameter .265"

APTITUDE RATING No. 8455
Stranding 16x34
41x34
Insulation Thickness 1/64"
Jacket Thickness 1/32"
Nominal Diameter .280"

APTITUDE RATING No. 8424
Stranding 26x34
Insulation Thickness .020"
Jacket Thickness .040"
Nominal Diameter .305"
Also used as microphone cable.

APTITUDE RATING No. 8427
Stranding 26x34
Insulation Thickness .020"
Jacket Thickness .040"
Nominal Diameter .370"
Interconnecting power cable for all electronic uses.

APTITUDE RATING No. 8425
Stranding 26x34
Insulation Thickness .020"
Jacket Thickness .040"
Nominal Diameter .335"
Interconnecting power cable for all electronic uses.

APTITUDE RATING No. 8888
Stranding 41x34
Insulation Thickness 1/32"
Nominal Diameter .114x.231"
Underwriters' Type POT-64

APTITUDE RATING No. 8426
Stranding 26x34
Insulation Thickness .020"
Jacket Thickness .040"
Nominal Diameter .355"
Interconnecting power cable for all electronic uses.

APTITUDE RATING No. 8452
Stranding 41x34
Insulation Thickness 1/64"
Jacket Thickness 1/32"
Nominal Diameter .245"
Underwriters' Type SV

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Coil Table

10 Meters (using 7-Mc crystals)

L1—10 turns, #22 enam., 1" dia., Millen 45004 form.
L2—6 turns #16 enam., 1" dia., 1/2" long on Millen 45004 form with two-turn link.
L3—Millen 4300 series, center link.
L4—B&W—10BVL with #3266 jack bar and link.

15 Meters (using 7-Mc crystals)

L1—B&W—40JEL.
L2—B&W—15JEL.
L3—Millen 4300 series, center link.
L4—B&W—40BVL.

20 Meters (using 7-Mc crystals)

L1—same as L1 above.
L2—B&W—20JEL.
L3—Millen 4300 series, center link.
L4—B&W—20BVL.

40 Meters (using 7-Mc crystals)

L1—B&W—40JEL.
L2—B&W—40JEL.
L3—Millen 4300 series, center link.
L4—B&W—40BVL.

80 Meters

L1—B&W—80JEL.
L2—B&W—40 JEL.
L3—Millen 4300 series, center link.
L4—B&W—80BVL (used in parallel with C28)

A 6L6 (or 1614) acts as a buffer on 80, 40 and 20 meters, and as a tripler to 15 meters and a doubler to 10 meters. The 6L6 is link coupled to push-pull *Eimac* 4-65A pentodes in the class C amplifier. The 4-65A tubes have instant heating 6-volt filaments that operate directly from the car battery. The filaments of the 4-65A tubes as well as the 811 modulators are turned on with the high voltage and are off during standby periods, thereby conserving battery power. Since no protective bias is available for the 4-65A tubes, a 6Y6 clamper tube is added to the screen circuit to protect the tubes in case of excitation failure. (See *Fig. 5-11-B*) Carbon resistors *(R11* and *R12)* are placed in each grid lead to the 4-65A tubes to eliminate a tendency towards parasitic oscillation when the excitation is removed.

Fig. 5-11-C. The cover of the transmitter is removed to show the placement of some of the components.

Although this particular transmitter did not require neutralization of the 4-65A tubes, if any instability is encountered the tubes may be easily cross-neutralized by placing two small metal tabs near the envelopes of each tube and cross connecting the tabs to the grid lead of the opposite tube. This circuit is shown in dotted lines in *Fig. 5-11-B*.

One leg of each filament of the 4-65A tubes is grounded at the socket, and the other filament lead is bypassed to ground directly at the socket by a 0.001 $\mu\mu$fd. condenser. Each screen lead is also bypassed to ground by a 0.001 $\mu\mu$fd. condenser. All four condensers, *C13, C14, C15* and *C16* should return to the chassis at a single point between the two tube sockets.

The plate tuning condenser, *C17,* is insulated from the chassis and connected to B plus. It is bypassed to ground by *C18*. This removes the d-c potential from across the plates of the condenser, and helps to prevent an arc-over under modulation peaks.

The Modulator

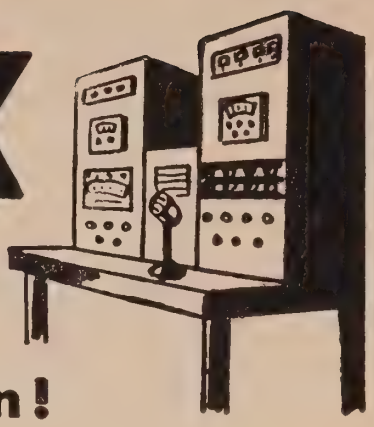
A pair of zero bias 811 tubes are used in the modulator to supply 150 watts of audio. A triode connected 6L6 is the driver for the 811's. The modulation level control, *R19,* is in the

Fig. 5-11-B. Wiring schematic and parts list.

C1—43 $\mu\mu$fd., El-Menco CM15-E-430J.
C2—250 $\mu\mu$fd., El-Menco CM15-E-251J.
C3, C6, C7, C8, C9, C12, C13, C14, C15, C16, C19, C21, C24, C25, C26, C27—0.001 μfd., ceramicon, Erie 800-001.
C4, C10—50 $\mu\mu$fd., variable, Bud LC-1644.
C5—100 $\mu\mu$fd., El-Menco CM15-E-101J.
C11—100-100 $\mu\mu$fd., dual midget, Johnson 100HD-15.
C17—55-55 $\mu\mu$fd., 078" spacing, Bud JC-1572A.
C18, C23—0.001 μfd., 2500v., Sprague ZFM-21.
C20, C22—1.0 μfd., 200v., Sprague 2TM-M1.
C28—50 $\mu\mu$fd., vacuum padder, see text.
J1—3-circuit mike jack, ICA #1872.
J2, J3—Amphenol SO-239 (83-1R).
M—0-1 ma., meter, d.c.
R1—100,000 ohms, 1/2w.
R2, R6—150 ohms, 2w.
R3, R7—30,000 ohms, 5w.
R4, R8, R13, R21,—0.5 ohm, 5w.
R5—47,000 ohms, 2w.
R9—6000 ohms, adjustable, 25w.
R10—5 ohms, 1w.
R11, R12—47 ohms, 1w.
R14—15,000 ohms, 200w. (made of two 30,000-ohm adjustable Ohmite #0969 units in parallel).
R15, R17, R18—47,000 ohms, 1w.
R16—2000 ohms, 1/2w.
R19—0.5 megohm, volume control.
R20—600 ohms, 1w.
Ry1—Antenna relay, Advance 2000 series.
S1—double pole, 5-position rotary switch, Centralab 2505.

BUD Condensers

Won't *Guarantee* TOPS in Mobile Operation!



We don't claim that putting Bud condensers in a rig that is inefficient will magically change your results to top quality. We do assure you that the high quality of workmanship and materials that are a part of all BUD products will aid in building efficiency. High Q and low inductance are the natural results of this quality product. All things being equal, BUD condensers will lead the way to better and more enjoyable mobile work.

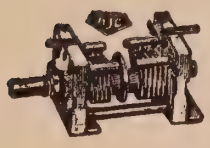
THREE-GANG TINY MITE CONDENSERS

Hams, Radio Constructors and Experimenters can find many uses for these compact, three-gang condensers. Designed particularly for high frequency use, they are adaptable for use in converters, preselectors and receivers covering the Amateur, Television and F.M. bands. Well constructed with soldered brass plates and ceramic brackets. Rotor shaft extended ¼" at rear. Height 1-5/16". Width 1-3/16". Length behind panel 3⅜". Mounting holes 2-3/16" apart. Capacity range of the condensers in this series: 5 mmfd to 11 mmfd; 5 mmfd to 17 mmfd; 6 mmfd to 25 mmfd.

TINY MITE TUNING CONDENSER SINGLE SECTION

This series of condensers has been designed for applications where space or weight are limiting factors and for tuning of ultra-high frequency circuits. Rigid construction, close fitting bearing, positive rotor contact and Steatite insulation are the outstanding features. High frequency efficiency insured by having brass plates and rods cadmium plated and soldered.

TINY MITE DUAL CONDENSERS

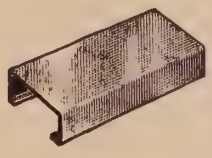


The construction of these units is similar to the regular Tiny Mite Tuning Condensers. The two end pieces are held together firmly with two tie-rods. A separate round plate is soldered on rotor rod to shield the two stator sections. Large surface front and rear sleeve bearings, provide smooth rotation.

BUD MINIATURE AMPLIFIER FOUNDATION

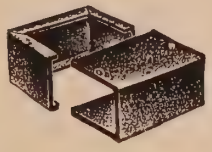
With the increased use of miniature tubes, smaller cabinets can be used when designing a compact amplifier. This amplifier foundation was designed expressly for this purpose. The chassis is a 5" x 7" x 2". Overall dimension 6" high, 7-3/16" wide, 5-3/32" deep. The cover is made of perforated metal. A streamlined handle makes this cabinet portable. Finished in black wrinkle.

BUD ALUMINUM MINIATURE CHASSIS



These small, open end aluminum chassis are just the thing for miniature tube applications or sub-assemblies. Made of hard aluminum with ¼" flange on bottom, allowing the chassis to be fastened down or a bottom plate to be attached. Extremely useful for small receivers, outboard uses, such as narrow band F.M. adapters or any use where space is limited. Finished in etched aluminum.

BUD MINIBOXES



There are thousands of uses in the fields of radio and electronics for these new boxes. They are made from heavy gauge aluminum. The design of the box permits installation of more components than would be possible in the conventionally designed box of the same size. It is of two piece construction, each half forming three sides. The flange type construction assures adequate shielding. Available in etched aluminum finish and gray hammerloid finish.

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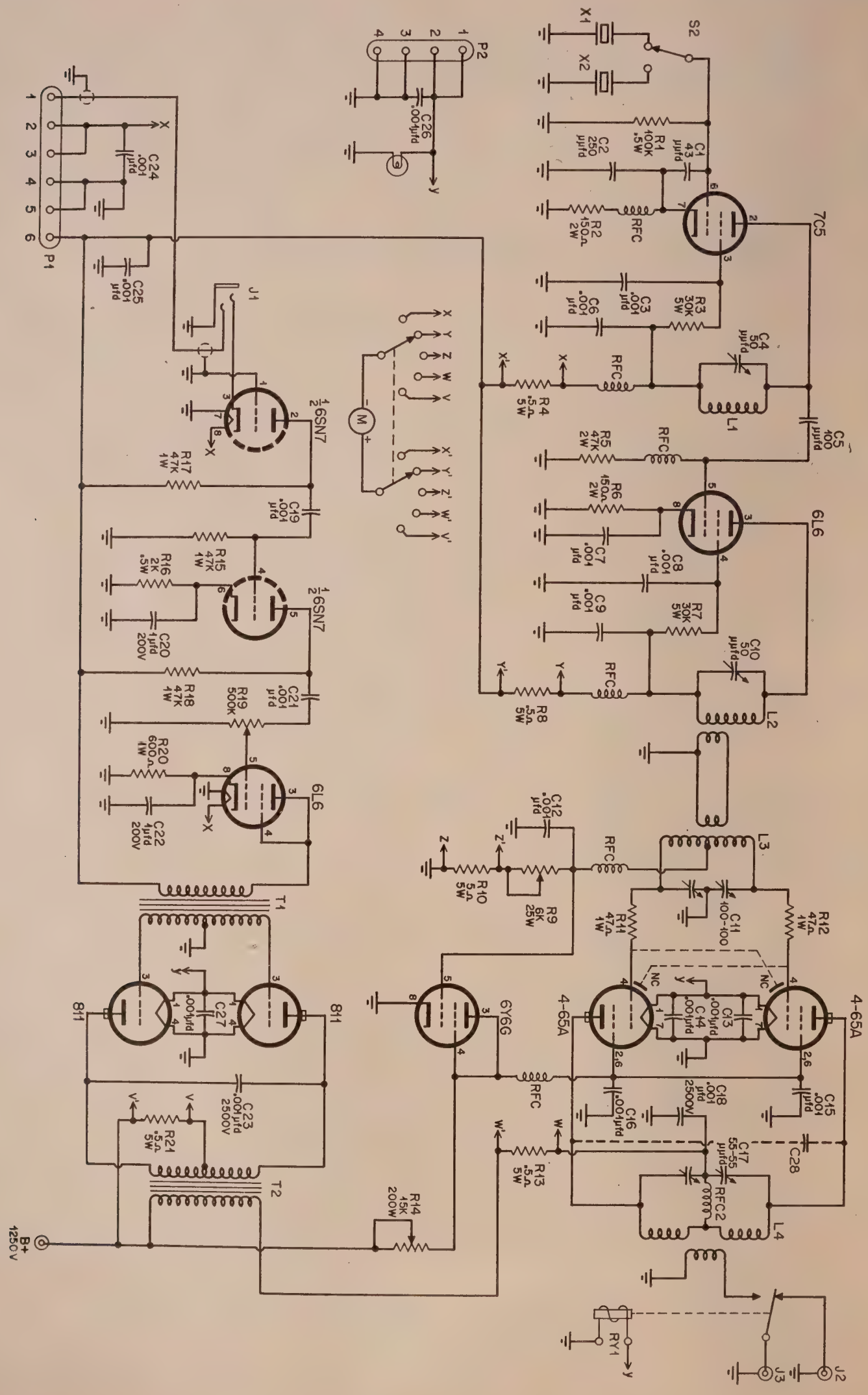
P1
P2
J1
J2
J3
S2
X1
X2
C1 43 μμfd
C2 250 μμfd
R1 100K .5W
R2 150Ω 2W
RFC
7C5
C3 .001 μfd
C6 .001 μfd
R3 30K 5W
C4 50 μμfd
L1
R4 .5Ω 5W
C5 100 μμfd
R5 47K 2W
R6 150Ω 2W
6L6
C7 .001 μfd
C8 .001 μfd
C9 .001 μfd
R7 30K 5W
C10 50 μμfd
L2
R8 .5Ω 5W
C24 .001 μfd
C25 .001 μfd
C26 .001 μfd
½6SN7
R17 47K 1W
C19 .001 μfd
R15 47K 1W
R16 2K .5W
C20 1 μfd 200V
R18 47K 1W
R49 500K
C21 .001 μfd
R20 600Ω 1W
C22 4 μfd 200V
C12 .001 μfd
R10 5Ω 5W
R9 6K 25W
L3
C11 100-100
R41 47Ω 1W
R12 47Ω 1W
T1
811
C27 .001 μfd
6Y6G
4-65A
C13 .001 μfd
C14 .001 μfd
C18 .001 μfd 2500V
C16 .001 μfd
C15 .001 μfd
C17 55-55 μμfd
C28
R13 .5Ω 5W
RFC2
L4
C23 .001 μfd 2500V
R21 .5Ω 5W
T2
R14 15K 200W
B+ 1250V
RY1

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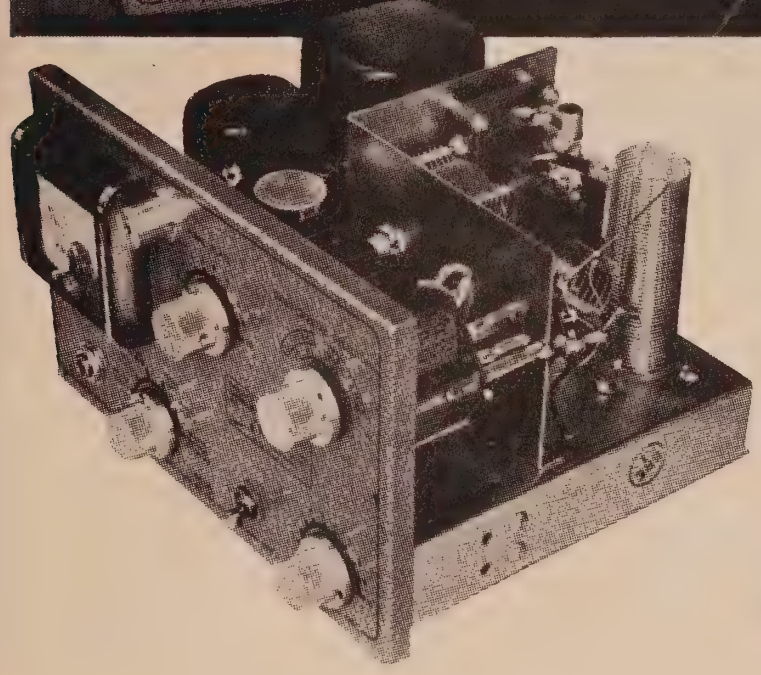

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- Finest components available
- 6BK5 oscillator
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- Complete metering, including watts output into 52 ohm antenna load
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MT-5A	COMPLETE TRANSMITTER	$99.50
PS-4A	(6vdc) Dual Vibrator Power Supply, Complete	67.50
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PS-CA	(12vdc) Dynamotor Power Supply, Complete	79.50
LS-1	Antenna Tuning Unit (75 and 10 meters)	15.00
LS-2	Antenna Tuning Unit (20 and 40 meters)	15.00

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input circuit to the 6L6 driver stage. A twin triode 6SN7 tube acts as a microphone input stage and as a resistance coupled speech amplifier stage. Condenser *C20, C22, C19* and *C21* are chosen to shape the frequency response of the modulator to drop the response at high and low frequencies. Condensers *C23* and *C18,* plus the leakage reactance of *T2* form a high frequency filter which cuts off at about 3600 cycles. This helps greatly to reduce sideband splatter.

A single 0-1 milliammeter is mounted in the dust cover of the transmitter, and is switched across shunts *R4, R8, R10, R13* and *R21* to read oscillator plate current, buffer plate current, final grid current, final plate current and modulator plate current. Since *R13* and *R21* are in the 1250-volt leads, it is necessary to use a ceramic deck switch to prevent arc-over between the contacts and ground. The exact value of the meter shunts will depend upon the internal resistance of the 0-1 milliammeter. The values specified are for a meter of 250 ohms internal resistance.

In order to keep the contact resistance of the power plugs at an absolute minimum, special high amperage plugs and sockets are used, and paralleled pins in each plug and socket combination are used to carry the filament currents of the tubes. The exciter tubes draw 4.1 amperes at 6 volts, and the final and modulator tubes plus antenna relay draw 16 amperes. Voltage drops in the filament circuits must be kept to an absolute minimum.

Mechanical Design

The mechanical layout is shown in *Figs. 5-11-C* and *5-11-D*. The placement of the main components may be seen from the top view. Across the front of the chassis, from left to right are: Filament pilot light; plate tuning, *C17;* meter switch, *S1;* grid tuning *C11;* doubler tuning, *C10;* oscillator tuning, *C4;* and crystal switch, *S2*.

On top front of the chassis, from left to right are: Final amplifier tank coil; 4-65A tubes; doubler coil with 6L6 behind it; 7C5 crystal oscillator tube in shield, with plate coil to right; and crystal socket. Across the back of the chassis in the same order are the modulation transformer, the push-pull 811's, the 6Y6 clamper tube, the 6L6 speech driver and the 6SN7 speech amplifier. The 6Y6 tube was added as an afterthought and was mounted in the audio section in a small area that was clear.

Beneath the chassis *(Fig. 5-11-D)* the tuning knob may be seen the small *Cinch-Jones* plug that connects the meter mounted in the dust cover to the meter switch mounted below the deck. In this picture, the 80-meter coils are in place, and padding condenser *C28* is mounted directly from one plate cap to the other of the 4-65A tubes.

Beneath the chassis (Fig. 5-11-D) the tuning *condensers C4, C10, C11* and *C16* are mounted on insulated posts to horizontally align their shafts. The rotor of *C11* is grounded. All condensers are driven by insulated shaft couplings. *C17* requires a high voltage coupling, such as the *Johnson 104-250.*

The 811 tube sockets are sub-mounted one inch to allow the plate caps of the tubes to clear the dust cover. The driver transformer, *T1,* is mounted between the 811 tube sockets and the 6L6 driver socket. The screen resistor, *R14,* is mounted above the modulation transformer on the back wall of the chassis.

The top and bottom dust covers, are hinged to the chassis along the back edge, and are held along the front edge by self-tapping screws.

The two coaxial plugs, *J2* and *J3* are mounted on the left wall of the chassis, as is *Ry1*. These may be seen in the bottom view. Condensers *C13-C16* are mounted directly on the

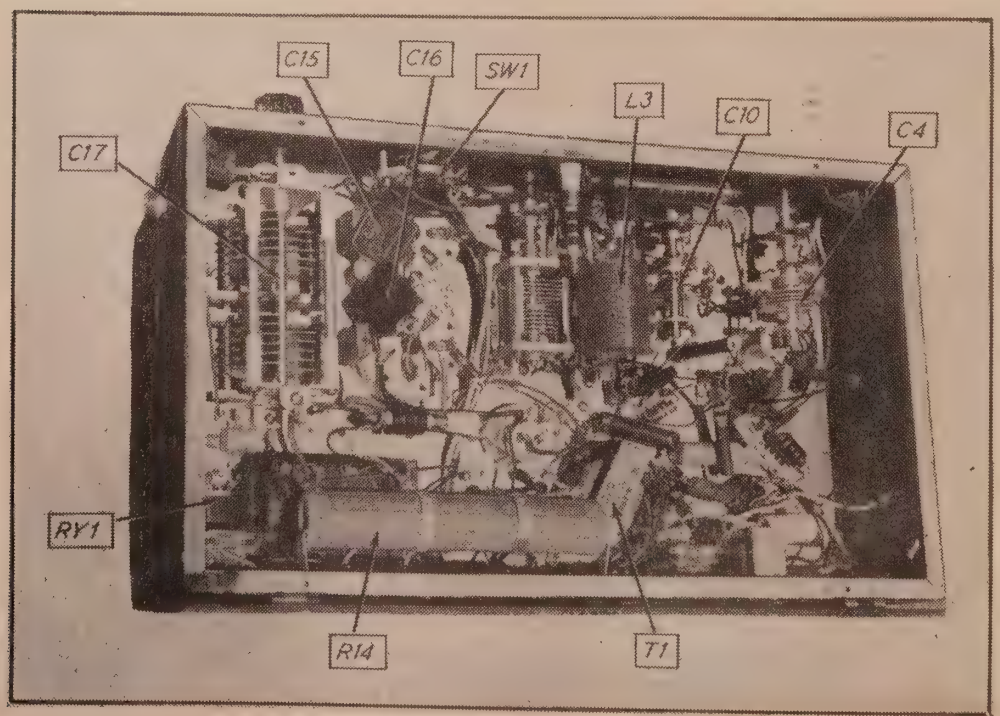

Fig. 5-11-D. Placement of the parts under the chassis of the 300-watt mobile transmitter.

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STANCOR'S ST-203-A Mobile Transmitter

THE COMPACT VERSATILE ST-203-A is again available—because you wanted it. A proven mobile transmitter, Stancor ST-203-A is being used by thousands of hams today.

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Power is obtained from a dynamotor or vibrator supply for mobile work or from an AC supply at a fixed location. Performs efficiently with the surplus PE-103A dynamotor and T-17B carbon microphone.

Briefly, the circuit lineup consists of a 6V6 harmonic oscillator working from 7 mc. crystals, a 2E26 Class C amplifier, a 6J5 grounded-grid speech amplifier, and a push-pull 6V6 Class A-1 modulator.

Attractively styled in silver-gray hammertone finish with gray plastic control knobs and brushed metal carrying handle. Size only 8⅝" x 7⅜" x 6¾". Weight with tubes and crystals, 9¼ pounds.

The ST-203-A, completely assembled, wired and tested, **AMATEUR NET PRICE,** less accessories **$66.75**

Kit, including prefabricated chassis, mounting plate, dust cover, prepared lead wires, all constructional components and detailed, illustrated instruction manual, **AMATEUR NET PRICE,** less accessories **$47.50**

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"Keep up the good work"

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4-65A tube sockets. Placement of the remaining parts under the chassis is not critical. Be sure to wire all high voltage leads, including the meter shunt leads with high voltage wire, such as *Belden 8901* plastic insulated wire.

Testing and Operation

When the transmitter is wired and checked, the r-f tubes should be inserted in their sockets, and relay *Ry1* temporarily disconnected from the filament line. *J3* should then be connected to the output link for test purposes. A 6.3-volt 4-ampere filament transformer may be used to power the exciter tubes, and a 6.3-volt 15-ampere filament transformer used for the high powered tubes. Apply 400 volts to the exciter and tune the transmitter up on the band to be used. Oscillator plate current should be under 20 ma., buffer current about 40 ma., and final amplifier grid current about 30 ma. with no plate or screen voltage on the 4-65A tubes. Before high voltage is applied, the 4-65A tubes should be tested for instability. Plug in *L4* and tune *C17,* while watching the grid current of the 4-65A tubes. If the grid current kicks as *C17* is tuned through resonance, the tubes must be neutralized. Two tab condensers must be added, one for each tube. These may be constructed as shown in *Fig. 5-11-E,* placed next to the glas envelope of each tube, and cross connected to the opposite tube grid beneath the chassis.

The capacity of the neutralizing condenser is varied by moving the plate closer to or away from the glass envelope of the tube. The neutralization should be rechecked on the 10-meter band, since the setting of these plates is the most critical on that band.

Once the amplifier is stabilized, the 6Y6 tube should be plugged in its socket, and about 500 to 800 volts applied to the 4-65A's. The plate circuit should be resonated and an external load applied to load the amplifier to about 100 ma. The final plate voltage should be raised to 1250 volts, and the amplifier loaded to about 200 ma. of plate current. The screen voltage should now be measured between the plate of the 6Y6 and ground. It should be 250 volts, and the screen current should be 70 ma. for the two tubes. The grid current should read about 20 to 25 ma. If the screen voltage is too low, the jumpers on the two resistors comprising *R14* should be moved in unison, reducing the circuit resistance. The grid drive and screen current are interlocking adjustments—more grid drive, more screen current, and lower screen voltage. The drive and *R14* should both be adjusted until 20 ma. of grid current and 70 ma. of screen current are flowing. Resistor *R9* in the grid circuit should be set to a value of 5500 ohms during the above adjustments. If the grid drive to the final is too great, *R7,* the 6L6 screen resistor may be increased in value. This will drop the output of the 6L6 buffer stage.

The speech amplifier and modulator tubes should now be placed in their sockets, and the transmitter turned on. The resting plate current of the 811 modulators should be about 20 ma. increasing to about 180 milliamperes under modulation. The final should not be loaded any heavier than 230 ma. plate current. This is just slightly over 300 watts input.

Re-connect relay *Ry1* when the test is completed. Remove the jumper from the output link coil to *J3.* It may now be put in the automobile and re-tested with the PE-103A and fan-driven generator. The generator regulator should be set to hold the plate voltage to about 1200 to 1300 volts at a speed of 60 miles per hour.

Control Circuits

A simplified control circuit for this transmitter is shown in *Fig. 5-11-F,* using a PE-103A dynamotor as a low voltage supply unit. The relays and circuit breakers in the PE-103A dynamotor are utilized in the control circuit for the transmitter.

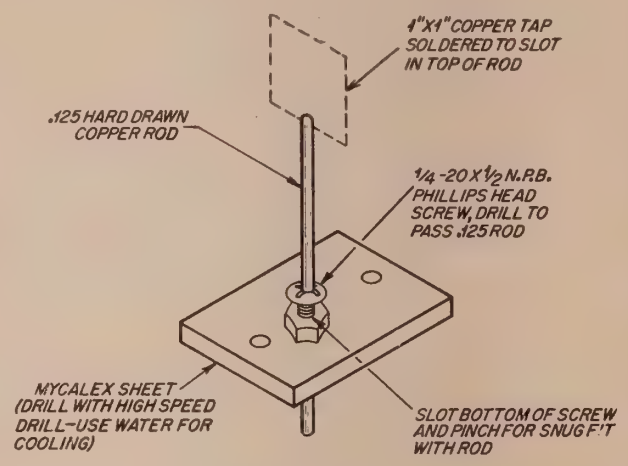
1"X1" COPPER TAP SOLDERED TO SLOT IN TOP OF ROD
.125 HARD DRAWN COPPER ROD
1/4-20 X 1/2 N.P.B. PHILLIPS HEAD SCREW, DRILL TO PASS .125 ROD
MYCALEX SHEET (DRILL WITH HIGH SPEED DRILL—USE WATER FOR COOLING)
SLOT BOTTOM OF SCREW AND PINCH FOR SNUG FIT WITH ROD

Fig. 5-11-E. Construction of the neutralizing tab.

Switch *S1* is a heavy duty three-pole single-throw switch. *S1A* turns on the 6-volt supply to the heater tubes in the transmitter and lights the filament pilot light, *I1.* A current of about 4 amperes flows through this section of the switch. *S1B* and switch *S2* (the "plate" switch) are in series, *S1B* acting as a protective switch, to prevent plate voltage from being applied to the transmitter before the filaments are turned on. After *S1* has been closed, closing *S2* and pressing the microphone button will put the transmitter on the air.

Switch section *S1C* is in series with the filament circuit to the 4-65A tubes. When it is closed, and *Ry3* is closed, the filaments of the 4-65A tubes are turned on. The action of *Ry3,* the BD-77 field relay, the "transmit" pilot light, *I2,* and the receiver squelch, relay are all controlled through *pin 3* of the PE-103A plug, which is actuated by relay *3E6* in the PE-103A. Relay *3E6,* in turn, is actuated by grounding *pin 4* of the PE-103A plug. This is done when *S1* and *S2* are closed and the microphone button is pressed.

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Eimac 4-65A

An ever increasing number of amateur radio operators are finding they can take Eimac quality on the highways with them by employing Eimac 4-65A radial-beam power tetrodes in their mobile transmitters. Physically and electrically the 4-65A is ideal for mobile. It is small, compact, rugged, radiation cooled; has a high power gain and needs only low driving power and simple circuit design. Two of the best of many 4-65A features are (1) instant heating thoriated tungsten filament, which makes warm-up unnecessary (2) simultaneous application of plate and filament power, which eliminates costly battery drain during stand-by periods. Although the smallest of Eimac's complete tetrode line, the 4-65A contains the Eimac specialities of non-emitting Y3 grid wire, pyrovac* plate, input-output shielding and thoriated tungsten filament.

TYPICAL MOBILE OPERATION

Plate modulated radio frequency amplifier.

DC Plate Voltage	600 volts
DC Screen Voltage	250 volts
DC Grid Voltage	—100 volts
DC Plate Current	117 ma
Driving Power	2 watts
Plate Power Input	70 watts
Plate Dissipation	20 watts
Plate Power Output	50 watts

Investigate the possibilities of the Eimac 4-65A on the new 40 meter phone and other bands by writing our Amateurs' Service Bureau for additional information.

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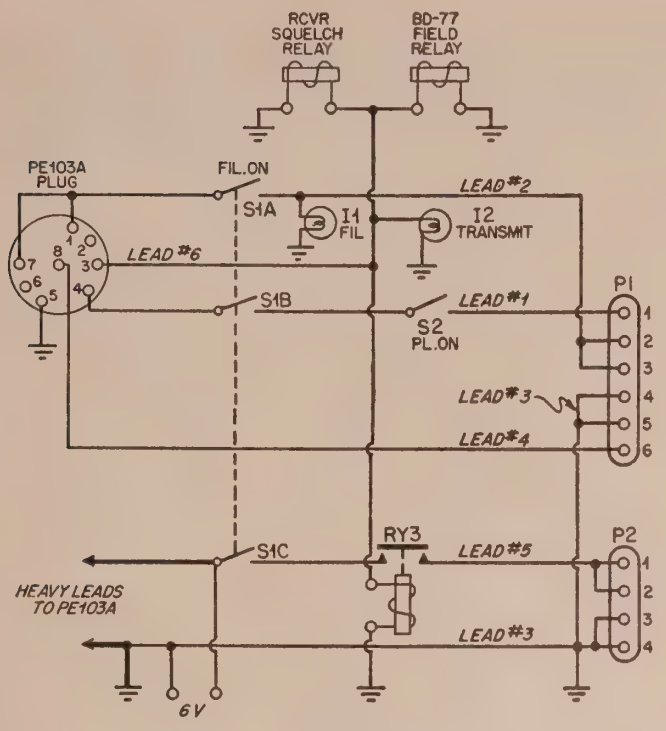

Fig. 5-11-F. This is the simplified control circuit for the 300-watt mobile transmitter. Note that the relays and circuit breakers in the PE-103A are used.

It is very important that the correct size leads be used to prevent excessive voltage drop between the battery and the transmitter.

Lead 1—This lead is a control relay lead. The only current flowing in it is the coil current of relay *3E6* in the PE-103A. No. 16 wire is satisfactory.

Lead 2—This lead carries the filament current to the heater tubes in the transmitter. The current in it is about 4 amperes. Use No. 12 wire.

Lead 3—This is a ground return lead. Do not depend upon the frame of the car for a ground return. Use No. 4 wire.

Lead 4—This is the 500-volt lead from the PE-103A. Use No. 16 wire.

Lead 5—This wire carries the filament current of the 4-65A tubes and the 811 tubes. About 15 amperes flows in this circuit. Use No. 4 wire.

Lead 6—This is a relay control wire. Use No. 12 wire.

Switches *S1* and *S2*, pilot lights *I1* and *I2*, and relay *Ry3* may be mounted on a small control panel near the driver's position in the car. A two-wire shielded microphone cable should be run from *J1* of the transmitter to a 3-circuit microphone jack mounted on this control panel. If it is desired to test the transmitter from the rear of the car, the extension cable may be unplugged from *J1* and the microphone plugged into its place.

Additional Control Circuits

For greater ease of operation, a few additional circuits may be easily added to this basic control hook-up. *Lead 5* may be routed through the control box, and a 0-250 ma. meter inserted in it to read the PE-103A high voltage current. The B plus lead from the BD-77 may also be brought into the control box (using high voltage wire, such as *Belden 8901*) and a 0-500 ma. meter put in series with it. A 0-2000 volt meter may be connected from this lead to ground to measure the high voltage. If small 2-inch meters are used, a very compact assembly can be made.

If any r.f. appears in the control box when the transmitter is on the air, each low voltage lead should be bypassed to ground with a 0.001 $\mu\mu$fd. ceramicon *(Erie 800-001)* and the high voltage leads with a 500-$\mu\mu$fd. 10,000-volt ceramicon *(Erie 413-501)*.

As a final touch, the thermocouple and ammeter may be taken from the *Antenna Relay Unit* of a 274N command set. The thermocouple should be inserted in the coaxial antenna lead, and the meter may be mounted on the control box. This will give a very handy means of checking the transmitter output.

The Antenna

A transmitter of this power requires an antenna of good efficiency. Whips having loading coils with high losses in the coil will not perform at all—the coil will simply disintegrate. See *Chapter 6* for mobile whips that will work efficiently with this transmitter.

5.12—The "Mobile Special" Transmitter

The "Mobile Special" transmitter is a v.f.o. controlled 35-watt transmitter capable of phone operation on any three amateur phone bands between 80 and 10 meters. In conjunction with the "Standard of Comparison" receiver described in *Chapter 3.8* it makes a complete, modern mobile installation requiring a minimum of space and primary power.

The transmitter is high level modulated with a voice selective frequency response designed to transmit an intelligible and readable signal under adverse conditions.

The "Mobile Special" has been designed with the above requirements in view. Its features include the following points:

1. Frequency control by an electrically and mechanically stable v.f.o.
2. Bandswitching r.f. circuits covering any three amateur phone bands from 80 to 10 meters, inclusive.
3. v.f.o. bandspread over almost entire dial scale for each band.
4. Provision for "spotting" the v.f.o. on the receiver.
5. *Pi* network output system providing readily adjustable antenna coupling.
6. Grid and plate metering of final amplifier.
7. Provision for receiver muting and antenna relay control.
8. Zero bias class B modulator, with high level speech clipping.

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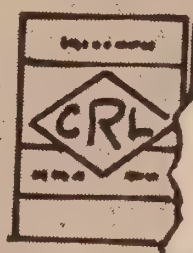

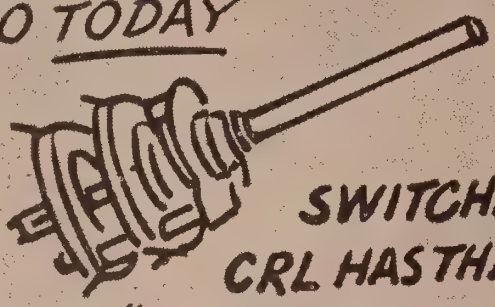

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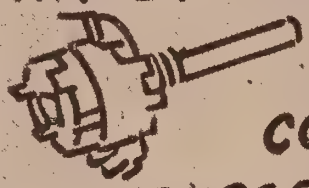

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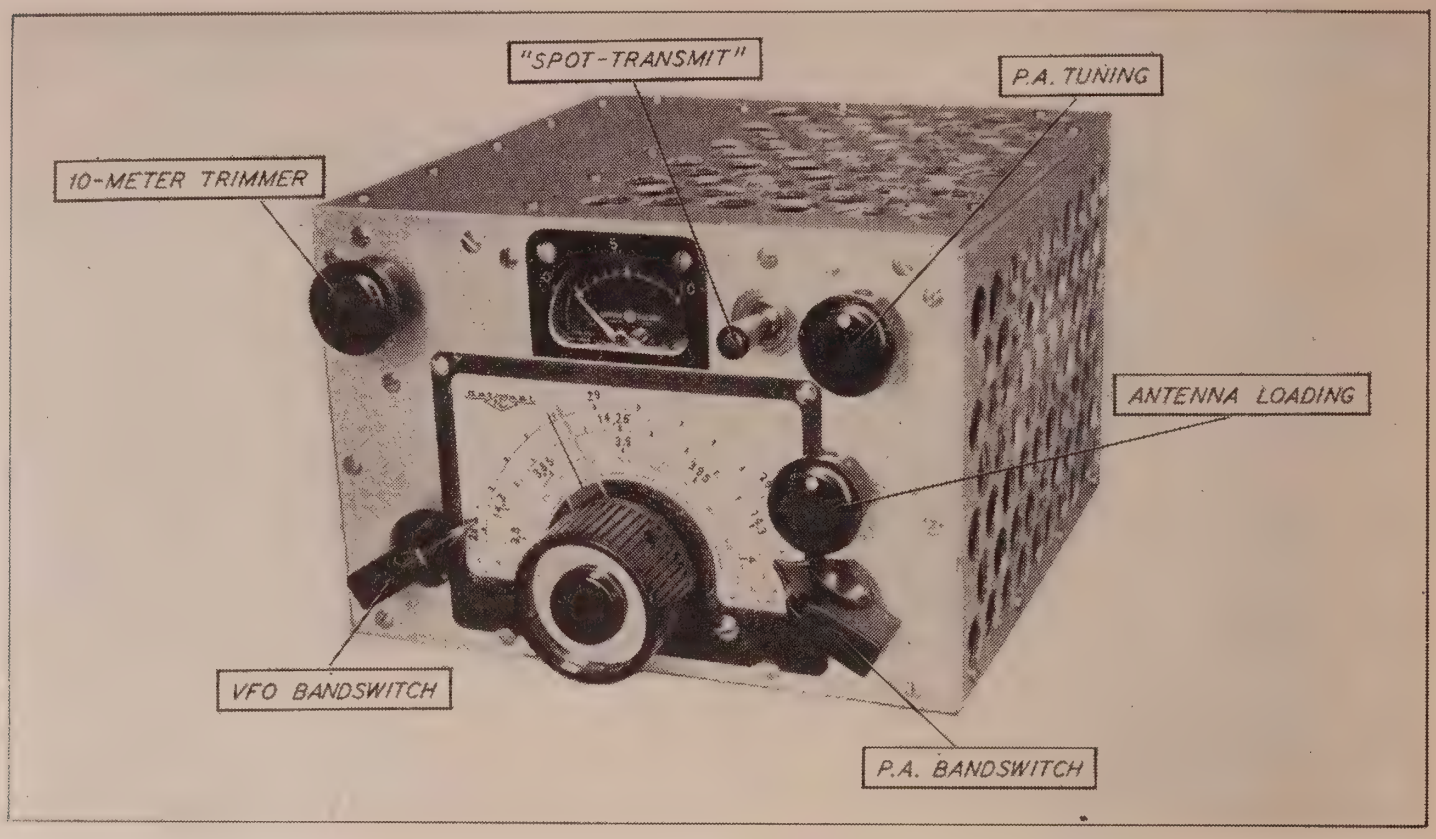

Fig. 5-12-A. A complete 35-watt VFO transmitter for fixed or mobile use.

9. Low-pass audio filter and splatter suppressor.
10. Input circuit adaptable for crystal, dynamic or carbon microphone.
11. "Push-to-talk" operation.

Any plate potential between 300 and 500 volts may be used with this transmitter, resulting in plate inputs of 15 to 35 watts. Using 500 volts and 35 watts input, the total plate current drain is 130 milliamperes during unmodulated periods. With full modulation and no clipping the current rises to 155 milliamperes on audio peaks. With heavy audio clipping, the peak plate current is 175 milliamperes. The heater drain is 6.3 volts at 2.3 amperes.

General Design

The transmitter has been designed into two units. The main unit is only 4½" high, by 6¼" wide, by 6½" deep, permitting mounting at the operating position on the steering wheel or below the dashboard. The small size is made possible by including only the r-f portion in the main unit. The cabinet and chassis form an integral unit, and are hand-made from sheet aluminum. The speech amplifier, modulator and control relays are mounted on a separate chassis which may be placed in some incon-

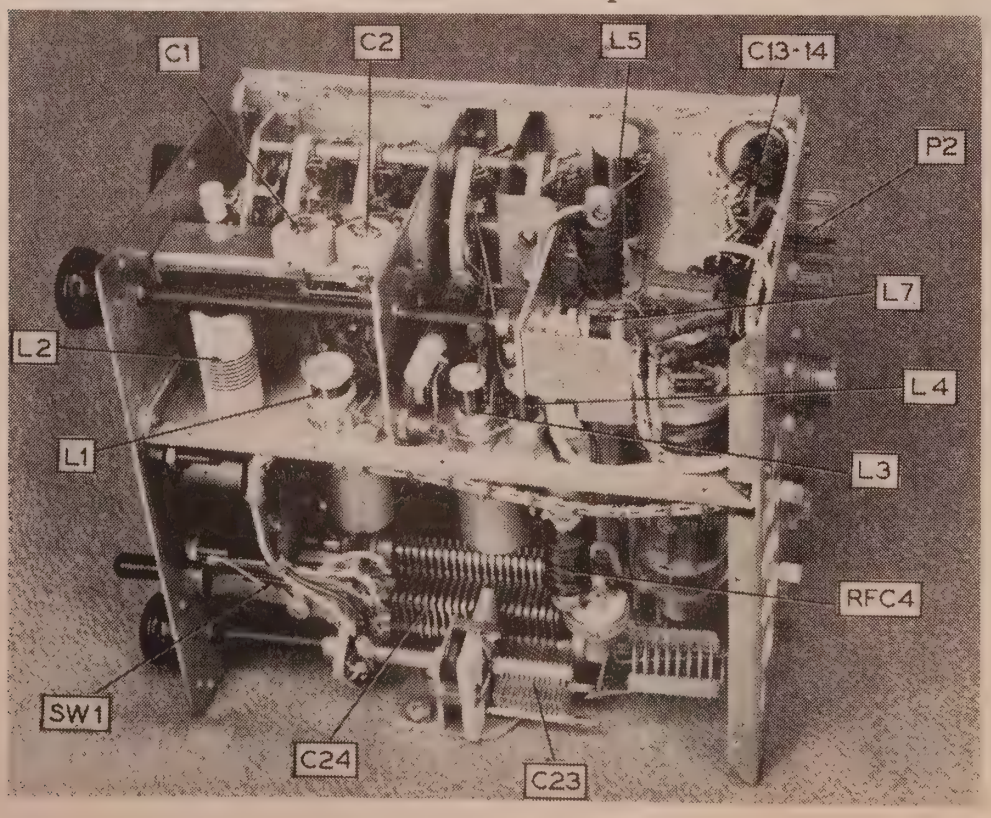

Fig. 5-12-B. The transmitter as viewed from the top left side. The v.f.o. coils (L1 and L2) are visible at the left. The adjustable 10-meter coil is mounted in the center of the chassis. It is tuned with the aid of a shaft extension to the front panel.

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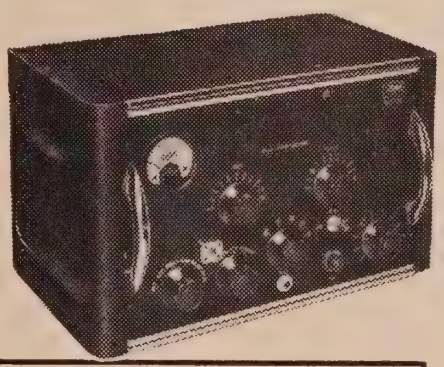

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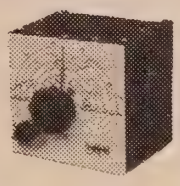

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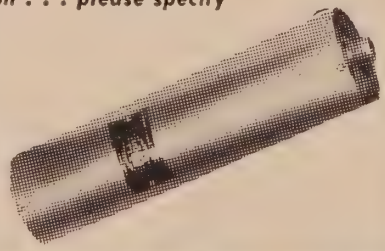

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spicuous spot such as on the firewall, under the seat, or in the trunk. This arrangement also prevents excessive heat in the r-f section, which would otherwise occur from the inclusion of the audio tubes and power resistors in the same cabinet. At the same time a degree of flexibility of the entire setup is attained, since any type of modulator (other than that described herein), furnishing adequate audio power may be used as desired, and in accordance with available components.

The tube lineup of the r-f section is a 6AU6 v.f.o. 6AK6 buffer-doubler, and a 2E26 final amplifier. A Colpitts circuit is used for the v.f.o. It will be noted that this appears similar to the Clapp circuit, from which the latter was derived, except that the tuning capacitor is connected across the oscillator inductor rather than in series with it. For CW operation, the series-tuned Clapp arrangement would offer an advantage in the way of frequency stability with instantaneous changes in plate potential during keying cycles; however, for phone operation, the plate potential is maintained constant under steady carrier conditions, in which case no increased stability would be attained over the parallel tuned circuit.

Silver mica and temperature compensated type capacitors are used wherever required in the v.f.o. Ceramic forms are used for the inductors. The tuning capacitor should be a heavy solid unit such as the *Millen No. 21000* or *Bud No. CE 3003*. A voltage regulator tube mounted in the modulator section is included for maintaining a constant plate potential on the oscillator.

For 3.8 to 4-Mc operation, the v.f.o. operates at a frequency of from 1.9 to 2 Mc., which is spread over the entire range of the dial. Coil *L1 (Fig. 5-12-E)* is the oscillator inductor for this range. Bandsetting is attained by adjusting the inductor's iron slug. The oscillator plate circuit is untuned, and is capacitively coupled to the 6AK6 doubler-driver which is tuned to the center of the 4-Mc phone band. This provides uniform grid drive over the band. For 14.2 to 14.3-Mc operation, the v.f.o. operates from 7.1 to 7.15 Mc. The 6AU6 plate circuit is tuned to 14 Mc., and the 6AK6 is used as an amplifier tuned to the center of the 14-Mc phone band. For 28.5 to 29.7 Mc. the v.f.o. tunes from 7.125 to 7.425 Mc., bandspread over the entire dial, the oscillator plate is tuned to 14 Mc., and the 6AK6 is used as a doubler tuned to 28 Mc.

No retuning for proper grid drive is required over the 14 and 4-Mc bands. Retuning on 10 meters is necessary only when shifting from one end of the band to the other. This is easily accomplished by adjusting the *L7* slug which is controlled from the front of the panel. From the schematic diagram, *Fig. 5-12-E,* it will be noted that load resistors, *R5* and *R6,* are connected across the 6AK6 14 and 4-Mc circuits. The purpose of these resistors is not that of broad-banding as it may appear, but rather it is a convenient means of cutting down the excessive drive available on these two bands, without the requirement of an extra control.

The Final Amplifier

The driver stage is capacitively coupled to the 2E26 final amplifier. The 2E26 plate tank and output circuit embodies the familiar *pi*-network coupling system, which provides a convenient means for adjusting the coupling from the front panel. It also provides a degree of harmonic attenuation. Capacitors *C23* and *C24,* together with the size of the inductors, have been chosen for optimum performance commensurate with the limited space available

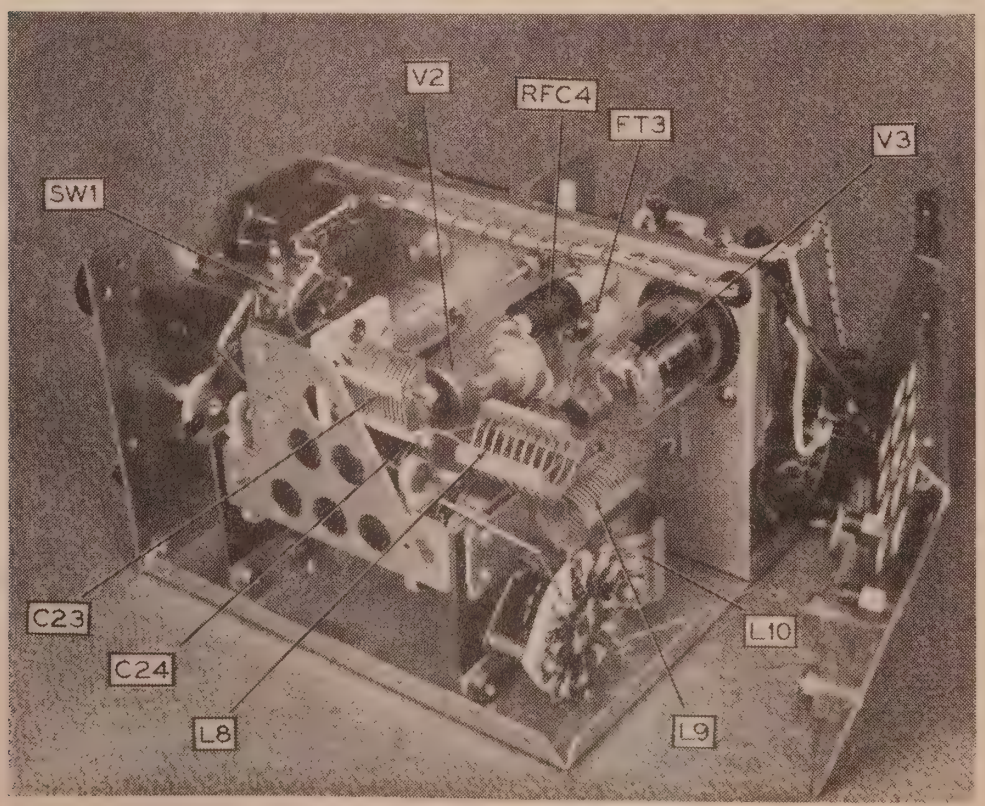

Fig. 5-12-C. This view of the transmitter specifically shows the positioning of the coils around the bandswitch.

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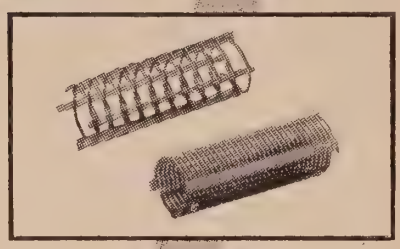

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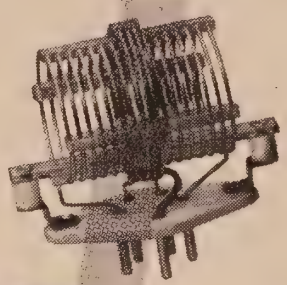

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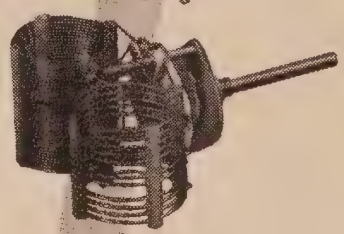

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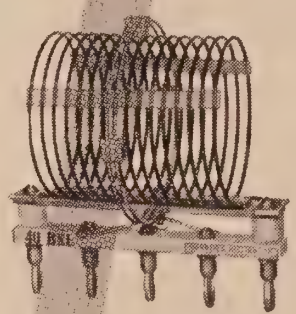

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The final amplifier plate inductors are band-switched. Although separate inductors are set up for each band it will be noted that one is added to another as the frequency band is lowered. In addition the inductors are mounted at right angles to each other to minimize coupling between them. This makes it possible to short out the unused inductors in a simple manner, and it does not lower the *Q* as would be the case if one continuous inductor were tapped with the unused sections short circuited out.

In some mobile installations the loading of the final amplifier may not be sufficiently decreased over the range of the variable loading capacitor. This may be experienced on both 14 and 4 Mc., so two sets of banana jacks, one for each band, are mounted on the rear panel to permit the insertion of fixed capacitors which will then be automatically connected across the variable loading capacitor *C24* as the band-switch is set for the desired band. The approximate amount of loading capacitance is thus obtainable for each individual installation with fine loading adjustable with *C24*. Parallel plate potential feed is used through *RFC4*.

The control relays and metering circuits are set up by the "spot-transmit" switch, *Sw1*. The center position is neutral, and the transmitter is de-energized. When the switch is in the up, or "spot" position, relay, *Rly1,* is energized. This then starts the generator through its own *start* relay, and applies the high voltage to the v.f.o. and buffer-doubler stage. *R13* is also switched into the circuit to assimilate the load normally drawn by the final amplifier and audio system, so that the generator load equals that found during transmitting periods. No plate potential is applied to the final amplifier, but the v-f-o signal may be heard in the receiver making it possible to spot the v.f.o. or set it to zero beat with another signal. At the same time, a meter is placed across the 2E26 cathode resistor *(R8)* and indicates the amount of grid current, full scale reading being 5 ma. On 28 Mc. the grid current may be properly adjusted by the panel control for *L7*.

When the switch *(Sw1)* is placed in the down, or "transmit" position, relay *Rly2* is energized, the generator starts, high voltage is applied to the entire transmitter, and the circuits are completed for the energizing of antenna and receiver disabling relays. *R10* is also switched in series with the meter, making its full scale range 100 ma. The total cathode current may now be read to ascertain the sum of the screen and plate currents when the final amplifier is tuned to resonance. Push-to-talk operation at the microphone is available through the microphone jack when the switch is in the neutral position.

The Modulator

The modulator tube is a type 1635 which is similar to the 6N7, but requires less plate and heater current. It may be operated at higher plate potentials with more audio output. In the "Special" it operates as a class B amplifier with zero bias, driven by a 6AK6, which in turn is preceded by a two stage speech amplifier consisting of a single 12AT7 dual triode. More than enough gain is available for a high impedance dynamic or crystal microphone. A carbon microphone may be used as described later in the text.

For 500-volt operation plate potential is applied to the 1635 through a 1000-ohm resistor *R23*. During unmodulated periods the static current drawn by the modulator tube is only 13 ma., and the plate potential is just slightly lower than that of the supply source

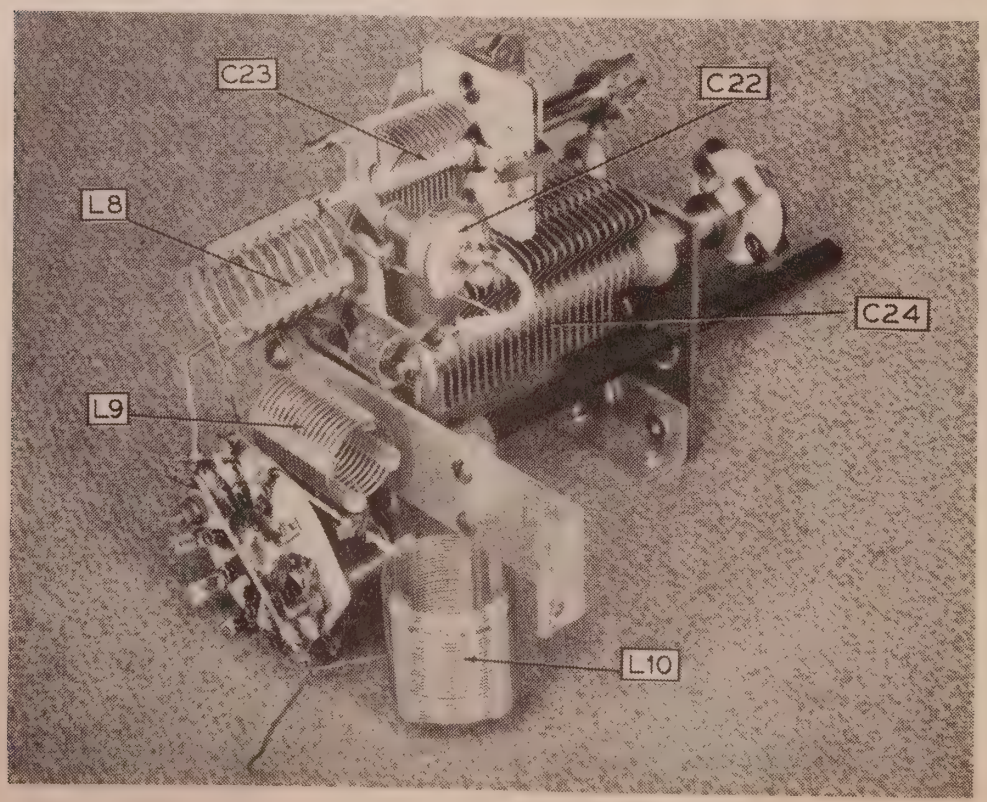

Fig. 5-12-D. The pi-network assembly for the 2E26 stage.

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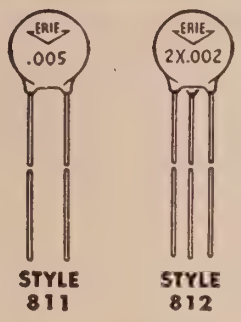

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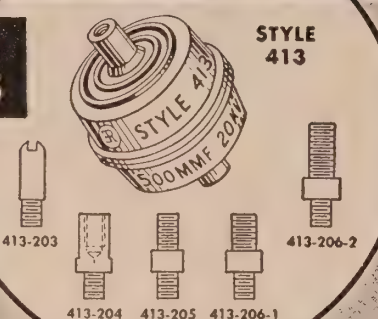
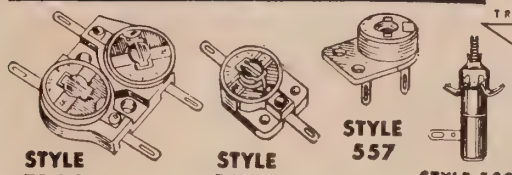
STYLE CB STYLE FA

ERIE UNIVERSAL 20 KV CERAMICONS



ERIE CERAMICON and TUBULAR TRIMMERS



STYLE TD2A STYLE TS2A STYLE 557 STYLE 532

ERIE

TRADE MARK

ELECTRONIC COMPONENTS

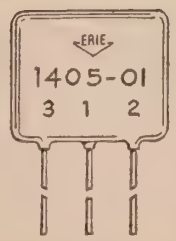
ERIE FEED-THRU CERAMICONS

STYLE 362 STYLE 327

ERIE STAND-OFF CERAMICONS

STYLE 323 STYLE 324 STYLE 325 STYLE 326 STYLE 2322 STYLE 2336

ERIE PRINTED CIRCUITS



ERIE DIODE FILTERS
1403-01 1403-02 1403-03

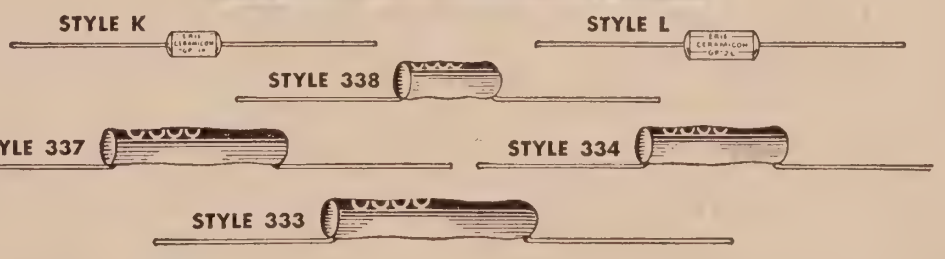
ERIE TRIODE PLATE COUPLERS
1404-01 1404-02 1406-01 1406-02

ERIE VERTICAL INTEGRATOR
1405-01

ERIE PENTODE PLATE COUPLERS
1407-01 1407-02 1407-03

ERIE AUDIO OUTPUT CIRCUITS
1408-01 1408-02

ERIE CERAMICONS



ERIE RESISTOR CORP.

TRADE MARK

ERIE RESISTOR CORPORATION . . . ELECTRONICS DIVISION

Main Offices: **ERIE, PA.**

Sales Offices: Cliffside, N. J. ◦ Philadelphia, Pa. ◦ Buffalo, N. Y. ◦ Chicago, Ill.
Detroit, Mich. • Cincinnati, Ohio • Los Angeles, Calif.

Factories: **ERIE, PA. ◦ LONDON, ENGLAND • TORONTO, CANADA**

Coil Winding Data

L1—25 turns #38 enamel on Millen #69042 iron slug tuned form
L2—8 turns #24 enamel space wound on Millen #45500 ceramic form
L3—36 turns #32 enamel on Millen #69048 iron slug tuned form
L4—30 turns #32 enamel on Millen #69048 iron slug tuned form
L5v—100 turns #32 enamel on Millen #69045 copper slug tuned form
L6—30 turns #32 enamel on Millen #69047 copper slug tuned form
L7—11 turns #24 enamel on Millen #69048 iron slug tuned form
L8—8¼ turns, B & W Miniductor #3010
L9—16 turns, B & W Miniductor #3007
L10—34 turns, B & W Miniductor #3016

The total plate dissipation is only a little above the manufacturer's rating of 6 watts. During modulation peaks, when the plate current rises, the voltage drop across *R23* also increases, and the potential applied to the modulator drops. The value of *R23* has been chosen so that the drop across the resistor during modulation peaks limits the modulation capabilities to just under 100%. Any further increase in audio level beyond that required to produce this degree of modulation, just simply squares off the audio peaks and produces high level speech clipping. This results in high average audio level and effectively increases the power of the modulated signal without over-modulating the carrier.

A high level low-pass filter, *T1, C27, C28* and *C29* is included to cut off frequencies above 3500 cycles for the prevention of a sideband splatter which may otherwise be caused by the high frequency harmonics created by the clipping in the modulator stage.

An added feature is the inclusion of a high level negative peak clipper to prevent possible breakup of the carrier should any transients on the negative peaks extend beyond 100% modulation. An OZ4 cold cathode tube is used for this purpose. Comparative tests have indicated no difference in its operation for this service over that circuit using the customary hot cathode rectifier tube. It is not advisable to

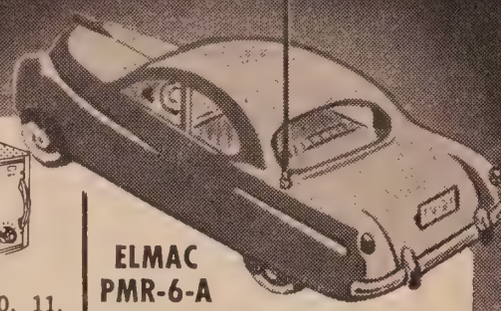
Fig. 5-12-E. Parts list and wiring schematic.

C1, C2—3-12 μμfd. NPO.
C1A—47 μμfd.—zero temp. ceramic.
C3—33 μμfd.—zero temp. ceramic.
C4—Millen #21075, remove 2 rotor plates for Bvd CE2003.
C5, C6—.001 μμfd. silver mica.
C7—100 μμfd. silver mica.
C8, C20A—.002 μμfd. ceramicon.
C9, C17—100 μμfd. ceramic.
C10, C11, C12, C15, C16A—.002 μfd. disc ceramic.
C13, C14, C16, C19, C20—.001 ceramic.
C18—National #NC600.
C21—500 μμfd. mica.
C22—.001 or .002 μfd. 1000v., Button or equivalent.
C23—100 μμfd. Millen #20100.
C24—325 μμfd. Millen #19325 or Bud MC1860.
C25, C25A—See text.
C26—.001 μfd. ceramicon.
C27—.004 μfd. 600 volt, paper.
C28, C29—.005 μfd. 1500 volt, paper or oil.
C30, C38—2 μfd. 600 volt, paper or oil.
C31—.01 μfd. 400 volt, paper.
C32, C35—500 μμfd. ceramic or mica.
C33, C37—8 μfd. 450 volt, electrolytic.
C34, C36—10 μfd. 25 volt, electrolytic.
R1—27000 ohms, ½ watt.
R1A—6800 ohms, ½ watt.
R2, R15—100,000 ohms, ½ watt.
R3—560 ohms, ½ watt.
R4—4700 ohms, ½ watt.
R5—15,000 ohms, 1w.
R6—50,000 ohms, 1w.
R7—20,000 ohms, 1 watt.
R8—20 ohms, ½ watt, carbon, see text.
R9, R9A—56,000 ohms, 1 watt.
R10—2500 ohms, ½ watt.
R11—3000 ohms, 2 watt.
R12—15,000 ohms, 10 watt.
R13—5000 ohms, 50 watt.
R14, R20—1 megohm, ½ watt.
R16—500,000 ohms, potentiometer.
R17—10,000 ohms, ½ watt.
R18—500 ohms, ½w.
R19—47,000 ohms, ½ watt.
R21—680 ohms, 1 watt.
R22—15,000 ohms, 10 watt.
R23—1000 ohms, 10w.
FT#1, FT#2—feedthru bushing, see text.
FT#3—feedthru bushing, Millen #32100.
J1—2 circuit jack, tip open, ring closed circuit.
J2, J3, J4, J5—banana jack.
P1—Coax chassis receptacle.
P2, P5—Jones plug, #P-310-AB.
P3, P4, P4A—Jones socket, #S-310-AB.
RFC1, RFC3, RFC4—2.5 m.h., Millen #34102.
RFC2—same as above and see text.
RLY-1, RLY-2—6 volt d.c. relay, D.P.D.T.
M—0-1 milliammeter, 100 ohms d.c. resistance, 1½" square, see text.
SW-A, B, D, F, H—Centralab ceramic 4 deck switch, 2 circuits, 5 positions each deck made up from 4 type RR ceramic wafers and K122 or K123 index.
SW-Y, Z—1 deck ceramic switch, 2 circuits, 5 positions, Centralab #2505 or Mallory #173.
SW-1—Switchcraft Lev-r Switch #3037L 3 position, D.P.D.T.
SW-2—Toggle, D.P.D.T.
V1—6AU6
V2—6AK6
V3—2E26
V4—VR150
V5—12AT7
V6—6AK6
V7—1635
V8—OZ4
T1—.39 henries. Thordarson Splatter Choke T20C62.
T2—Kenyon Universal driver transformer T264, use ratio primary to ½ secondary 2.6:1.
T3—Kenyon Universal modulation transformer 40W, use 15,000 ohms to 7000 ohm taps.
XS-9#1, XS-9#2—National Feedthru bushing #XS-9.

TERMINAL LEADS IN MOBILE EQUIPMENT

BIGGEST VALUES IN TOWN!

Everything for the Car and Home Base!



MODERN MOBILE MIKES by ELECTRO-VOICE

All feature high speech intelligibility, ruggedness, press-to-talk switch for operating relay and are provided with handy mounting bracket.

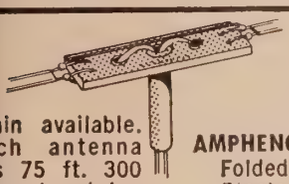
208—Low cost, S. B. carbon, close talking, noise-cancelling Differential type....**9.70**

210—S. B. carbon, extra rugged, high articulation. **16.76**

205—Like the 210, but with Differential feature **20.28**

600-D — One of the best, Dynamic, choice of high or low impedance. **22.64**

602—Like the 600-D, but with Differential feature. . . **26.46**



AMPHENOL Folded Dipole Amateur Antennas

gain available. Each antenna has 75 ft. 300 ohm lead-in. Flat-top portion is #16 copper-clad steel twin-lead. With instructions.

139-010	10 Meters	5.24
139-020	20 & 15 M.	5.88
139-040	40 Meters	7.64
139-080	80 Meters	11.03

JOHNSON Viking Mobile Kit

A mobile powerhouse, up to 60 watts. Band-switching, 4-position crystal selector, fully metered and with many other outstanding features. 240-141 KIT, less tubes, crystals, microphone and power supply. **99.50**

This kit as well as the famous Viking I, Viking II and VFO are available wired and air-tested, or unwired but with tubes, etc. Write W2BUS for special prices.

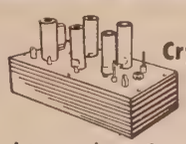
GONSET "COMMUNICATOR"

A truly fine and self-contained communications station complete with 19" whip antenna ready for operation. Weighs 16 lbs. • Output 5-7 watts on 144-148.3 Mc • Operates on 110 Volts AC and 6 Volts DC with no other power supplies required • 10 tube 6BQ7 cascode receiver with a noise clipper that really works • Sensitive built-in speaker • Only 10 x 9 x 7 inches • Uses carbon, crystal or dynamic mike • Over 100 mile range.

COMMUNICATOR, with tubes but less crystal and mike ...**199.50**

COMMUNICATOR, complete with crystal, BRUSH crystal microphone, cord and plug—NOTHING ELSE needed to go on the air. **205.95**

TECRAFT Crystal Controlled CASCODE CONVERTER



Low noise, 1 microvolt gives 20 db quieting, high sensitivity, 0.1 microvolt provides a signal 6 db over noise level. The ultimate for top performance. Power supply of 150 to 250 volts required.

CV-2 — 144-148 Mc. **42.50**

CV-10—10 & 11 Meters **37.50**

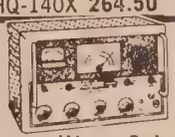
FOR THE SHACK

Hallicrafters HT-20 transmitter, 100 watts, TBI suppressed. Continuous coverage from 1.7 Mc. to 30 Mc. with full band switching. Choice of 10 crystals. Less microphone and crystals **449.50**

COMMUNICATIONS RECEIVERS

NATIONAL SW-54	49.95
NATIONAL NC-125	149.50
NATIONAL NC-183D	369.00
NATIONAL HRO-Sixty	483.50
HALLICRAFTERS S-38	49.50
HALLICRAFTERS S-40B	119.95
HALLICRAFTERS S-53A	89.95
HALLICRAFTERS S-76	179.50
HALLICRAFTERS SX-71	224.50
HALLICRAFTERS S-81	49.50
HALLICRAFTERS S-82	49.50
HAMMARLUND HQ-140X	264.50

ELMAC A-54 TRANSMITTER



A-54 is an excellent mobile or fixed station transmitter. Only 7½ x 7½ x 12", will tuck away anywhere but can take a husky 50 watts input. Bandswitching provides 10, 11, 20, 40, 75 and 80 meters. VFO-xtal selector switch provided.

A-54—Carbon mike input **139.00**

A-54H—Dynamic or crystal mike **149.00**

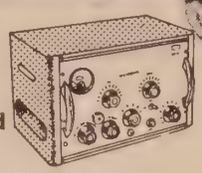
PSA-500—115 VAC power supply **39.50**

GONSET "COMMANDER"

Powerful mobile 35-50 watt transmitter covering 1.7 to 54 Mc. Not a kit. With tubes, less pwr. supply. **124.50**

GONSET VFO for Commander **29.95**

New SONAR SRT-120 Multi-Band XMTR



A compact TVI-proofed 10, 11, 15, 20, 40, 75 and 80 meter all-purpose transmitter measuring only 8½x8½x14" packing 100 watts phone or 120 watts CW. Suitable for mobile or fixed station with selection of power supply.

SRT-120—With tubes, less power supply **198.50**

SRT-120-M—In 8x8x10 mobile cabinet **198.50**

PS-500—115 volt AC power supply **49.50**

PS-501—115 V pwr supply with built-in push-to-talk relay and circuit.. **59.50**

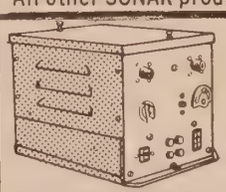
SRT-120-P—The SRT-120 and PS-501 in single handsome cabinet **279.50**

V-120—A VFO for all above transmitters **19.95**

MR-3—Receiver for 10-11-20-75 meters ... **89.95**

MR-4—Receiver for 20-40-75-80 meters ... **89.95**

All other SONAR products in stock.



ROBERT DOLLAR Model 222

New TWO METER quality mobile transmitter. With tubes, less crystal, mike and power supply. **89.50**

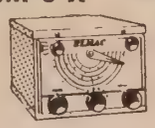
Model 226—Companion receiver. **99.50**

GONSET "SUPER SIX" CONVERTER

Covers 10, 11, 15, 20, 40 and 75 meters. Compact, stable, highly sensitive **52.50**

TERMINAL carries all GONSET products. Hams with Tri-Bands or Supers who have acquired 12 volt cars, write W2BUS for free modification instructions.

ELMAC PMR-6-A



6-Band Receiver

Elmac has designed this receiver to be the finest possible in its class without regard to cost. Dual conversion, ten tuned circuits, six bands covering all the amateur bands from 10 meters thru 160 meters plus the broadcast band, less than 1 microvolt to produce 3½ watts audio output, effective noise limiter and many, many other features.

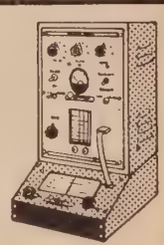
PMR-6-A—Less power supply **134.50**

PSR-6—6 Volt power supply **24.50**

PSR-12—12 Volt power supply **24.50**

PSR-116—115 VAC power supply **24.50**

HARVEY-WELLS



VFO now available for your BANDMASTER Transmitter! High stability Clapp type 6AG7 voltage regulated oscillator. Six bands — 10, 11, 15, 20, 40 and 75-80 meters. May also be used with other transmitters. About 300 volts @30 Ma. and 6.3 V @0.65 Amps required for power.

BANDMASTER VFO **47.50**

Bandmaster Senior Xmtr **111.50**

Bandmaster Deluxe Xmtr **137.50**

APS-50—115VAC Power supply **39.50**

DPS-50—6 volt Dynamotor **87.50**

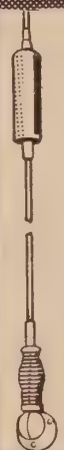
DPS-50—12 volt Dynamotor **54.50**

Mobile remote control panel **22.50**

Rack panel, 12½x19", mounts Bandmaster and APS-50 ..... **5.75**

FOR THE CAR:

MASTER MOBILE All-Band ANTENNAS



AB/W20	8.75
AB/W40	8.75
AB/W75	8.75
AB/W2374 Kc (C.A.P.)	9.95
Extra coils for above, each	3.30
142 Bumper Mount	3.25
140 Spring Bumper Mount	6.55
132 Spring Swivel Mount	8.75

Write W2BUS for complete Master Mobile dope sheets.

FOR HOME BASE: KRECO ANTENNAS

Features low angle of radiation; low standing wave ratio; solid brass for high weather resistance; all antennas threaded to fit brass or galvanized ¾" pipe available anywhere in lengths up to 21 feet; mounts as easily as a TV mast; absolutely no compromise with quality; no dangling feedline, cable enclosed in pipe mast.

CO-AX Antenna for RG-11 or 59/U Cable

CO—2 meters	14.95
CO—150-170 Mc	14.95
CO—6 meters	19.95
CO—10 meters	29.95

Ground Plane Antennas for RG-8 or 58/U Cable

GP—2 meters	14.95
GP—150-170 Mc	14.95

Stacked 4-Element Co-ax Antennas for RG-8/U cable

SC—2 meters	34.95
SC—150/170 Mc	34.95

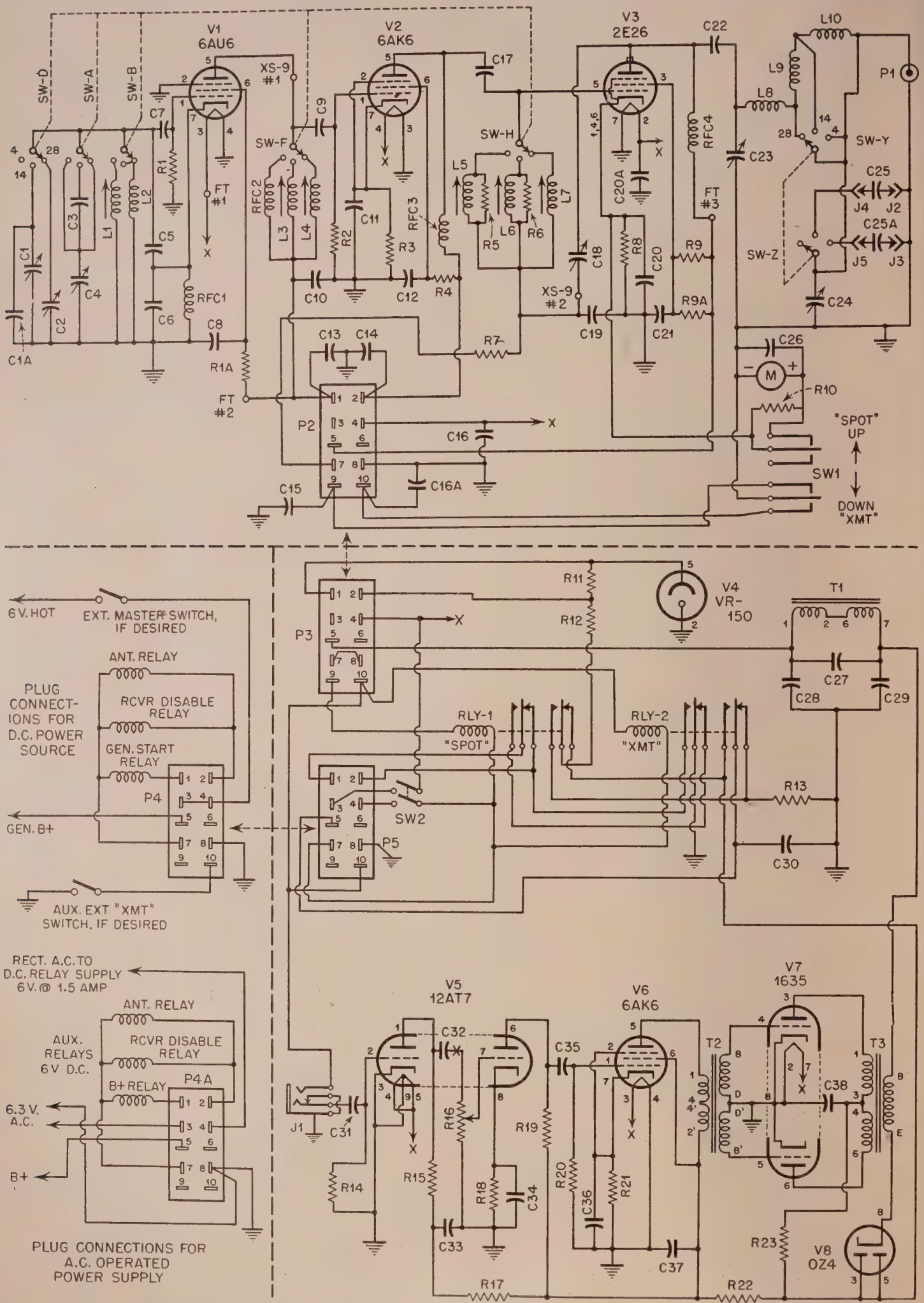
Antennas cut for middle of band unless otherwise specified — write W2BUS for the dope and quotations on beams, multi-element vertical or horizontal polarized hi-freq arrays, etc.

TERMINAL RADIO CORP.

Distributors of Radio and Electronic Equipment

85 CORTLANDT STREET • NEW YORK 7, N. Y.

Phone: WOrth 4-3311 Cable Address: TERMRADIO


V1 6AU6
V2 6AK6
V3 2E26
V4 VR-150
V5 12AT7
V6 6AK6
V7 1635
V8 0Z4
SW-D
SW-A
SW-B
SW-F
SW-H
SW-Y
SW-Z
SW1
SW2
XS-9 #1
XS-9 #2
FT #1
FT #2
FT #3
P1
P2
P3
P4
P4A
P5
J1
J2
J3
J4
J5
C1
C1A
C2
C3
C4
C5
C6
C7
C8
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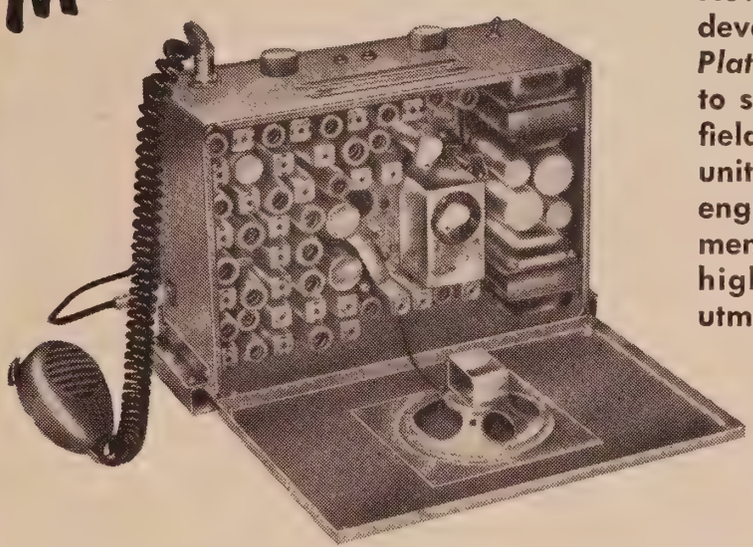
R21
R22
R23
RFC1
RFC2
RFC3
RFC4
L1
L2
L3
L4
L5
L6
L7
L8
L9
L10
T1
T2
T3
RLY-1
"SPOT"
RLY-2
"XMT"
"SPOT" UP
DOWN "XMT"
6V. HOT
EXT. MASTER SWITCH, IF DESIRED
ANT. RELAY
RCVR DISABLE RELAY
GEN. START RELAY
PLUG CONNECT-IONS FOR D.C. POWER SOURCE
GEN. B+
AUX. EXT "XMT" SWITCH, IF DESIRED
RECT. A.C. TO D.C. RELAY SUPPLY 6V. @ 1.5 AMP
AUX. RELAYS 6V D.C.
B+ RELAY
6.3 V. A.C.
B+
PLUG CONNECTIONS FOR A.C. OPERATED POWER SUPPLY

ANNOUNCING

The Newest, Most Advanced 2-Way Communication System Ever Designed!

PLATT MOBILE RADIO EQUIPMENT

MODEL 30-TRM-31



Now, after years of intensive research and development by America's foremost engineers, *Platt Mobile Radio Equipment is out of the lab* to set a new standard in the communications field! It incorporates in one rugged packaged unit all the desirable features that operators, engineers, maintenance men and installation men have demanded for ease of operation, high performance, simple installation and utmost economy.

PLATT MOBILE RADIO EQUIPMENT MODEL 30-TRM-31 (shown). Freq: 152-174 MC. 24 tubes. Dimensions: 14¼" x 9¾" x 5¾".

ALSO AVAILABLE:

Mobile Equip. Model 30-TRM-11. Freq: 25-50 MC.
Base Station Model 30-TRS-31. Freq: 152-174 MC.
Base Station Model 30-TRS-11. Freq: 25-50 MC.

OPERATES IN 152-174 MC BAND

Platt Mobile Radio Equipment Model 30-TRM-31 incorporates a transmitter and receiver mounted on a single chassis which is installed under one cover with a vibrator power supply affording 30 watts of R-F output in the 152-174 megacycle band.

Simplest, Easiest Installation!

Brackets are supplied for installation for front mounting under the dashboard or glove compartment, or in certain installations, under the driver's seat. The controls and loudspeaker are incorporated as an integral part of the cabinet. *Only one short lightweight cable and antenna assembly* are required for complete installation in any vehicle having a 6 volt DC battery system. (12 volts available.)

Finest Components!

The components utilized, without exception, are the very best heat-resistant parts, manufactured for operation at 85° C. without any change in performance.

Competitively Priced!

Platt Mobile Radio Equipment is comparatively low priced, making it an ideal choice for taxi fleets, police, fire departments, forestry, railroads, trucks, civil defense, etc.

Get All the Facts on this Advanced Equipment.
WRITE TODAY FOR YOUR LITERATURE!

PLATT *Manufacturing Corp.*

489 BROOME STREET • NEW YORK 13 • NEW YORK • WORTH 4-0827

use the OZ4 where the plate supply potential is less than about 325 volts, since it requires at least 300 volts to fire the tube.

Low valve coupling capacitors are used in the speech amplifier stages to drop off the low frequency response, so that the clipping of these frequencies (which contribute little to intelligibility) will be less, with little harmonic distortion being created within the pass band of the modulation system.

Construction

The front and rear panels of the r-f section, chassis and brackets are made of 1/16" aluminum which may be cut and bent to shape in the home workshop. All necessary dimensions are given in *Fig. 5-12-F*. Holes, whose locations are not specified, may be conveniently determined by the builder during the process of construction. Inspection of the photographs, together with the data of *Fig. 5-12-F*, will aid in finding the method of assembly and the location of various components.

The horizontal bottom piece is screwed to the bottom of the vertical section on which are mounted *V1, V2, etc.* The screw holes should be lined up so the v-f-o bandswitch brackets will be secured by the same screws. The bandswitch should be assembled and mounted on the brackets before the latter are secured. The bracket, shown at the right of *Fig. 5-12-G*, is held in place by the bandswitch assembly and by the right angle bend, *K*. The latter should be bent and its hole should be located so that it may be secured to the screw at the bottom left of socket *V3* (as shown in *Fig. 5-12-F*) which is mounted on ¾" pillars. Coil *L7* is mounted on the bracket in hole *L* which should line up with hole *L7* on the front panel. The *L7* slug is controlled from the front panel through a ¼" diameter bakelite rod in the end of which a small hole is drilled to pass over the threaded screw of the lug, and a set screw is used to firmly secure the rod. The other two bandswitch brackets are also secured along the vertical side of the chassis.

Ordinarily, the decks of a bandswitch are mounted so that the contacts and terminal lugs are at the rear of each deck; however, in this case the switch should be assembled with the contacts and lugs reversed, so that they appear towards the front of each switch deck. This is necessary so the terminal lugs may be placed at the most convenient position for wiring. Reference should be made to the pictorial wiring diagram, *Fig. 5-12-H*, for added information on the switch arrangement. The reversal of the decks may require alterations in the switch stops according to the switch assembly used. The switch shown in the photographs has not been reversed since its terminal locations are different than those found on the standard switches specified in the parts list.

The center line and the distance from the front panel are shown in *Fig. 5-12-F* for the mounting of the v-f-o tuning capacitor. It should be mounted on right angle brackets, at front and rear, so that the center of the rotor is 1" from the vertical side of the chassis. The rotor should then line up with the *MCN* dial drive mounted on the front panel. A ⅜" hole must also be made in the vertical chassis directly under the capacitor, so a wire may be connected from the capacitor stator to switch terminal 4*A*.

In the illustrated model a cover was made and placed over the v-f-o capacitor to keep out dust and dirt, and to prevent any possible feedback from the final amplifier to the VFO.

Dimensions of the assembly for the final amplifier tank components are shown in *Fig. 5-12-G*. The front bushing of *C24* is secured to the left bracket at hole *X*. The frame of the capacitor is also secured at holes *V* with *6-32* flat head screws. *C32* mounts in hole *W*, and may be secured at the bushing by lock nuts on both sides of the bracket, or by the feet already at the front of the capacitor. Flexible couplings, such as the *Millen No. 39007*, may be used between the capacitors and their extension shafts to the panel.

The final amplifier bandswitch, *Sw-Y, Sw-Z*, is mounted in hole *Z*. The switch deck should be in the standard position with the terminals at the rear of the deck. A ¼" diameter bakelite rod is connected by a sleeve type coupling to the switch, and passes through hole *Y* and through hole *F* on the front panel.

The 4-Mc inductor, *L10*, is cemented to the ¼" polystyrene strip which should be placed along the inside of the inductor winding.

The entire assembly is secured to the bottom chassis piece at holes *S* and holes *R* at the right bend of the piece supporting the polystyrene strip. These two *R* holes will fall just below the *V3* clearance hole. The screw through the lower *R* hole at this point also supports the tie point terminal strip to which is wired *R7* on the other side of the chassis. The exact location of the *S* and the specified *R* holes on the chassis should be made so that the controls to the front panel will be aligned with the components on the assembly.

Dimensions of the cutout for the meter are not given since several different types of meters may be used. The one shown in the photographs is a *G.E. 1½" square unit, Type DN-1, Model ABC11*, 0-1 ma., 100 ohms resistance. The *G.E. type No. 411X92* may also be used as well as the *MB Instrument Co. 1½" square Model 151, or round Model 152*. Any other meter, having the specified electrical characteristics, may be used. Some 2" type meters may also fit into the space since the instrument is mounted in back of the panel with only the scale perceptible through the panel cutout.

On the rear panel two banana jacks are insulated from the metal panel with polystyrene

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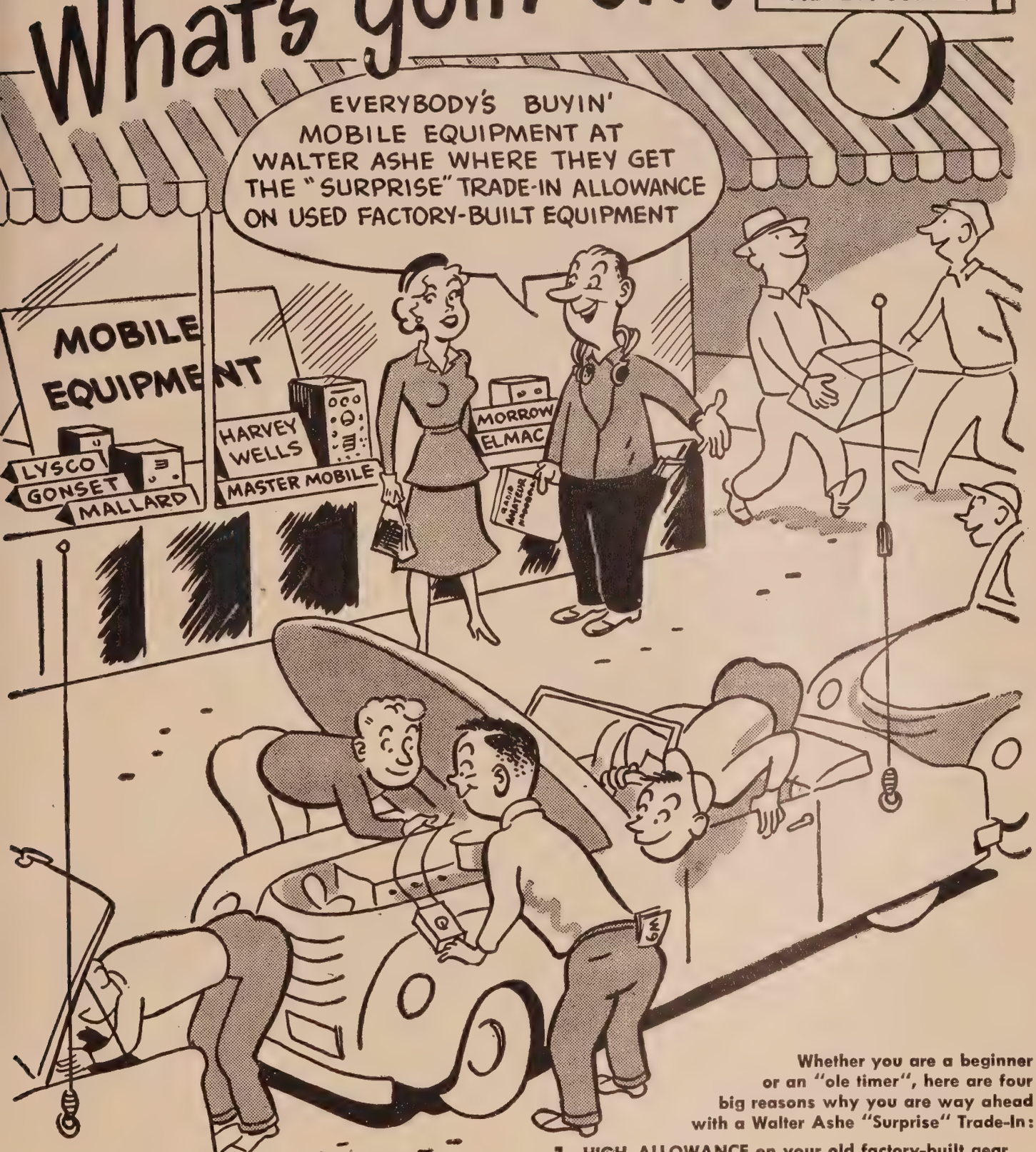

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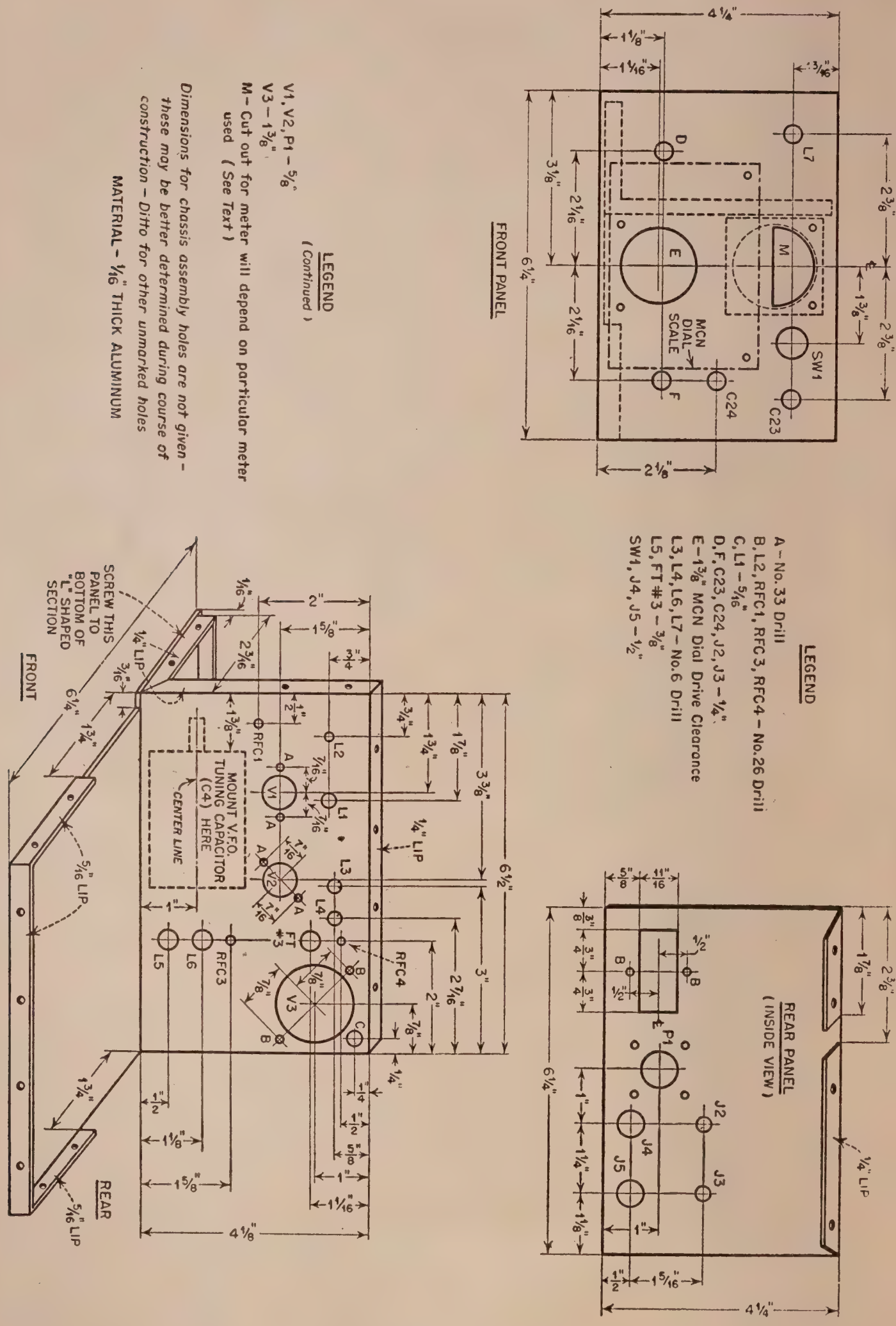
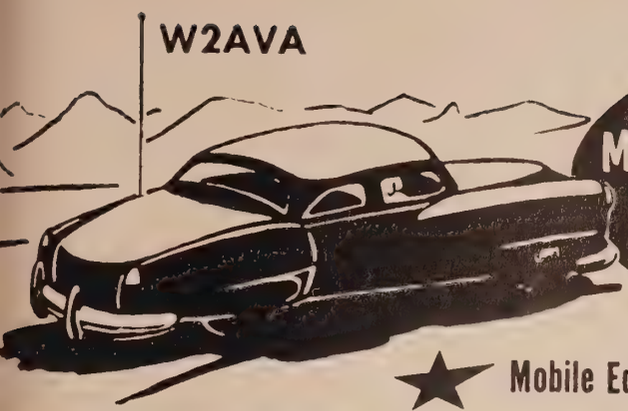

LEGEND
(Continued)
V1, V2, P1 – 5/8"
V3 – 1 3/8"
M – Cut out for meter will depend on particular meter used (See Text)
Dimensions for chassis assembly holes are not given – these may be better determined during course of construction – Ditto for other unmarked holes
MATERIAL – 1/16" THICK ALUMINUM
FRONT PANEL
MCN DIAL SCALE
LEGEND
A – No. 33 Drill
B, L2, RFC1, RFC3, RFC4 – No. 26 Drill
C, L1 – 5/16"
D, F, C23, C24, J2, J3 – 1/4"
E – 1 3/8" MCN Dial Drive Clearance
L3, L4, L6, L7 – No. 6 Drill
L5, FT #3 – 3/8"
SW1, J4, J5 – 1/2"
REAR PANEL (INSIDE VIEW)
SCREW THIS PANEL TO BOTTOM OF "L" SHAPED SECTION
FRONT
REAR
MOUNT V.F.O. TUNING CAPACITOR (C4) HERE
CENTER LINE
1/4" LIP
5/16" LIP

Fig. 5-12-F. Structural drawing of the panels and sub-chassis.



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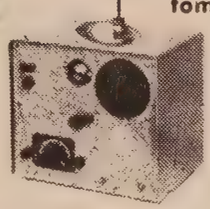

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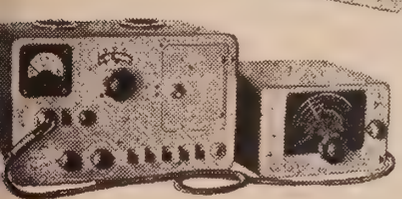

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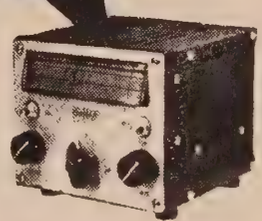

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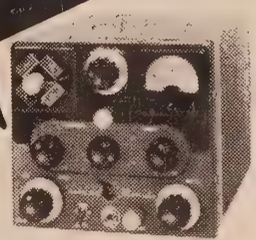

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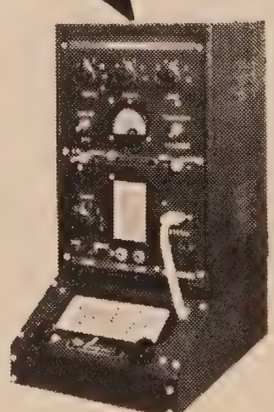

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bushings, as indicated in the diagram. The other two jacks are grounded directly to the panel but first they must be built up with an additional spacer to meet the level of the insulated jacks.

The side pieces and the top cover for the unit are separate pieces screwed in place individually. Measurements for these can be made after the other sections are assembled. Two holes should be made in the left side panel to provide access to the trimmers, *C1* and *C2*. Plenty of screws should be used to hold all the parts together so the final product will be sturdy and vibrationless. Either 3-48, 4-40 or 6-32 screws may be used, with tapped holes employed instead of nuts. Plenty of ventilation holes should be made in the cabinet sections around the final amplifier. These may be neatly made using a ½" chassis punch.

Wiring

The components on the vertical chassis should be wired before the panels are mounted. Refer to pictorial wiring diagram *Fig. 5-12-H*, as a guide. The ends of the leads to the power plug, *P2*, and also *R9, R9A*, should be left unconnected until later. *C7* lies flat along the chassis, while *C5* and *C6* stand edgewise on either side of *C1*. It is important that these capacitors as well as all the other components in the oscillator section be held firmly in place to avoid vibration. Leads to the bandswitch should be made as short and direct as possible and with wire no smaller than No. 18. At *FT No. 1* and *FT No. 2* it is preferable to use feedthrough type capacitors (any size) such as the *Erie style 362*. If these are not available, *National type XS-9*, or *Millen No. 32150* panel feedthrough bushings may be used.

All the 2.5 mh, r-f chokes are standoff mounting type. On *RFC2* the mounting base should be removed by heating it with a soldering iron. It will then fit in the space nicely and may be held in place with heavy wire leads. The ground connection for *L1* is made by soldering the bottom lead to the metal mounting at the base. On *L2* the ground is made at the inside of the form and to the mounting screw which holds the form in place.

The bracket with *C1* and *C2* should be mounted and wired after all the other components in the oscillator section have been wired.

The components of the final amplifier plate circuit should be wired after first mounting the front panel and the tank assembly. No special problems should be encountered after reference is made to the pictorial diagram and the photographs. A rubber grommet should be inserted in hole *C*, through which will pass the leads from *Sw-1*. The rotor of *C23* should be grounded to its mounting bracket. The plate lead from *RFC4* to the tube should be made of flexible wire and should be only long enough to permit removal of the plate clip from the tube cap. The leads at both ends of the neutralizing capacitor, *C18*, should be made of No. 14 wire to firmly support it. Wiring between the final bandswitch and *P1* and the insulated banana jacks should be left until last, at which time the rear panel may be mounted and the connections may also be made to *P2, R9*, and *R9A*.

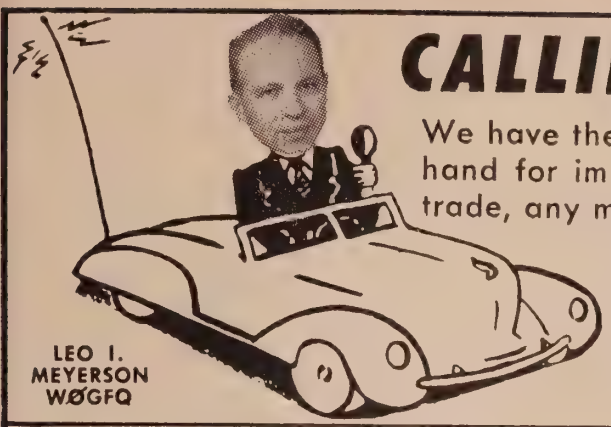
Constructional details are not given for the modulator and relay unit since the layout and wiring are quite conventional. The unit shown here is built on a 7" x 7" x 2" aluminum chassis, but other sizes and layouts may be used to fit in any special space where the modulator is to be placed in the car.

Resistors *R12* and *R17* should preferably be mounted above the chassis where good ventilation is available. As a precaution against fire they should be enclosed within a well ventilated perforated can or screen. Wire used in the class B plate and in the output circuits to the final amplifier should be insulated to withstand peak potentials of at least 1500 volts. From the parts list it will be noted that high quality and higher power rated audio transformers are used in preference to the small 12- or 15-watt units generally used in mobile applications. In past tests the small units have broken down under the high peak potentials and power requirements encountered with 400- to 500-volt operation when speech clipping was used.

Alignment and Adjustment

Remove the left side panel and the top cover. If a grid dipper is available all the inductors should be first checked as follows: Insert all the r-f tubes in their sockets. Set the v-f-o bandswitch for 4 Mc. (maximum clockwise rotation), and set the v-f-o tuning capacitor at maximum capacitance. Adjust the slug in *L1* so resonance is indicated at about 1.9 Mc. Then rotate the capacitor to minimum where the frequency should increase to about 2 Mc. Then adjust the slug in *L5* until resonance is obtained at 3.9 Mc. Next, rotate the bandswitch to the next counterclockwise position, or 14 Mc. Proceed as above adjusting trimmer *C1* so that *L2* resonates from about 7.1 to 7.15 Mc over the range of the tuning capacitor. Adjust slug in *L3* to resonate at 14 Mc. and slug in *L6* to resonate at 14.25 Mc. Now rotate bandswitch counterclockwise to 28 Mc position, and adjust *C2* so that *L2* resonates from approximately 7.125 to 7.425 Mc. over the range of the v-f-o tuning. Adjust slug in *L4* to 14.5 Mc, and tune *L7* (controlled from front panel) for resonance at 29 Mc.

In the absence of a grid dipper and also following the above pre-alignment, if made, proceed as follows: (this step is best done on the workbench, where an a.c. operated power supply may be conveniently employed). Connect



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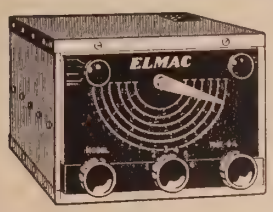

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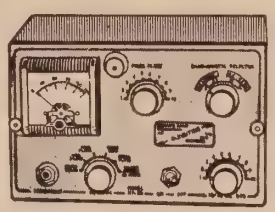

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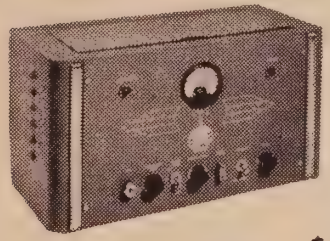

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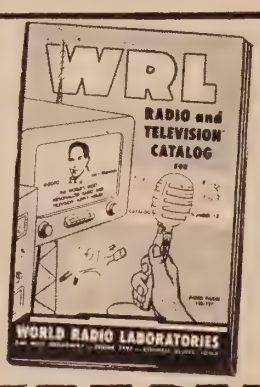

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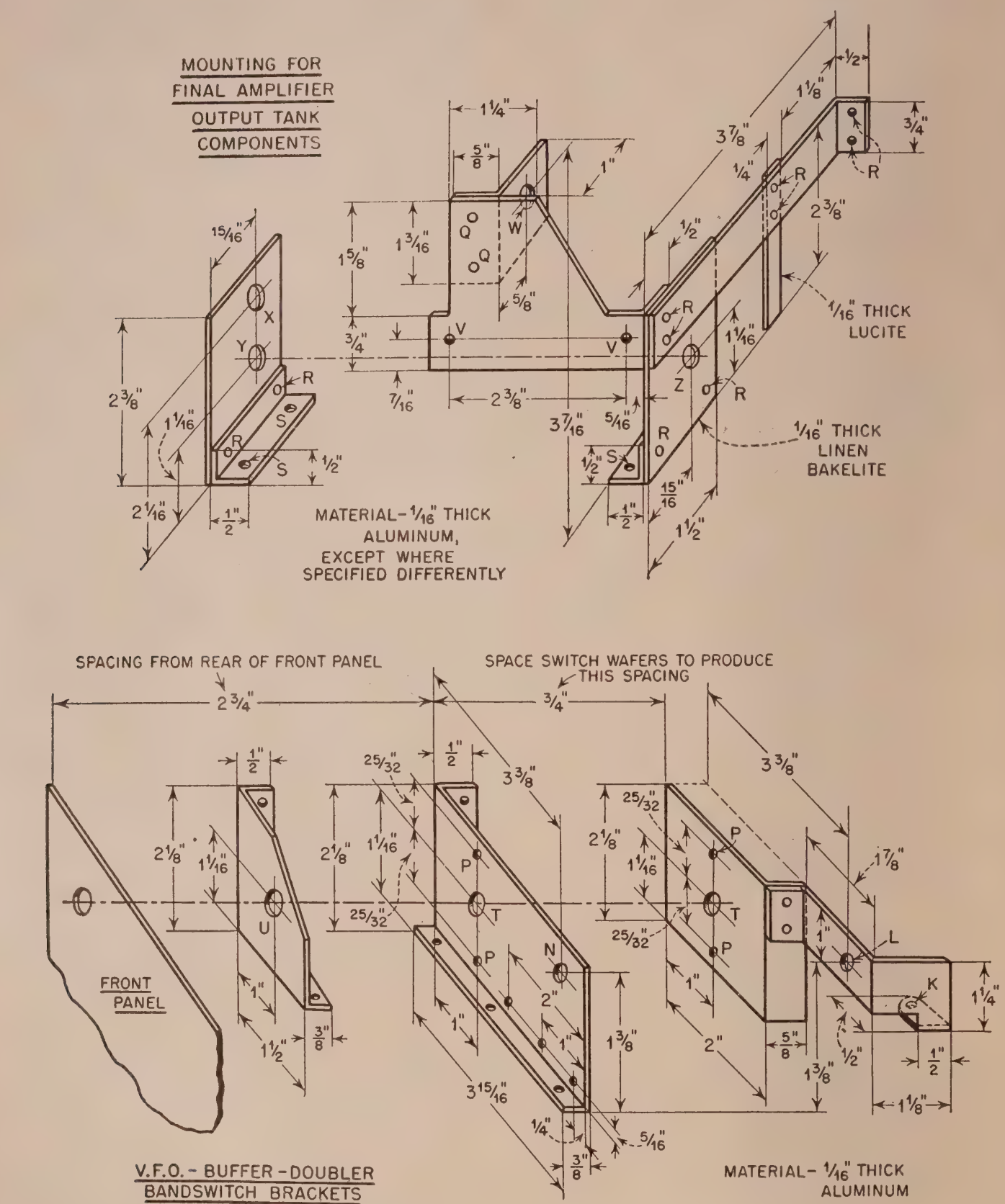
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1/16" THICK LINEN BAKELITE
SPACING FROM REAR OF FRONT PANEL
SPACE SWITCH WAFERS TO PRODUCE THIS SPACING
FRONT PANEL
V.F.O. – BUFFER – DOUBLER BANDSWITCH BRACKETS
MATERIAL – 1/16" THICK ALUMINUM

LEGEND

K – See Text
L – No. 6 Drill
N – 1/4" Drill
P – No. 33 Drill
Q – No. 26 Drill and Countersink
R – No. 26 Drill
S – No. 36 Drill, No. 6-32 Tap
Dimensions for location of these holes determined at builder's discretion
T – 5/16" for V.F.O. Bandswitch Clearance
U – 3/8" for Mounting V.F.O. Bandswitch
V – No. 26 Drill and Countersink – for C24
W – 5/16" for C23
X – 3/8" for C24
Y – 5/16" Clearance for Shaft to Final Bandswitch
Z – 3/8" for Final Bandswitch
NOTE – Line up W with C23 Hole on Front Panel
" " X " C24 " " " "
" " Y and Z with F Hole on Front Panel
" " L with L7 Hole on Front Panel

Fig. 5-12-G. Construction of the various bracket assemblies.

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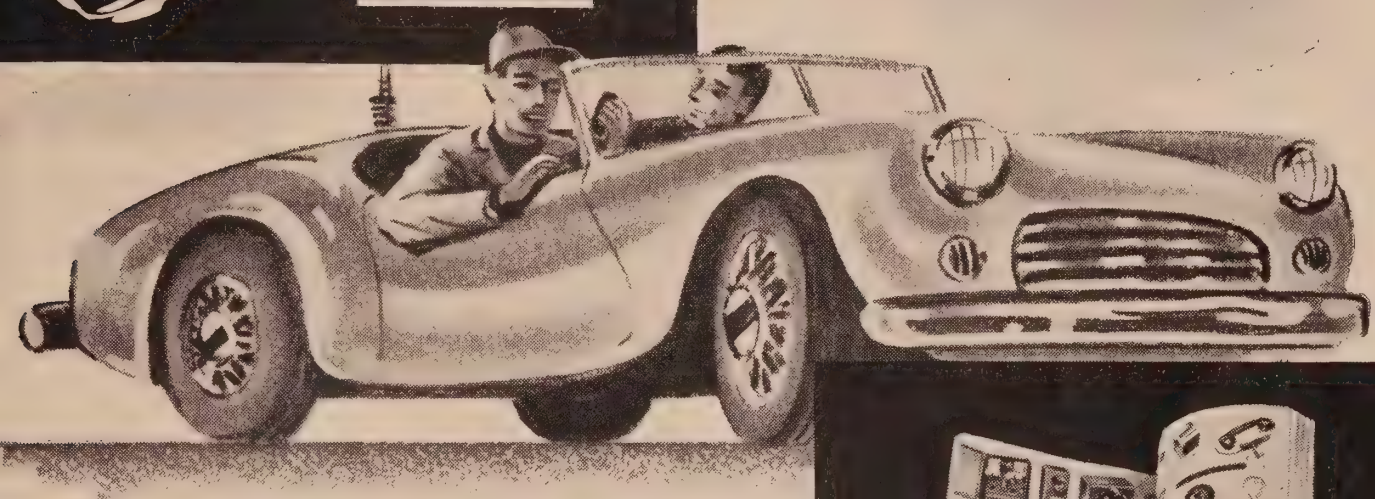

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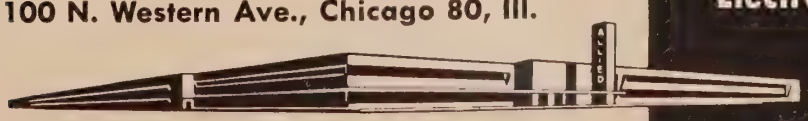

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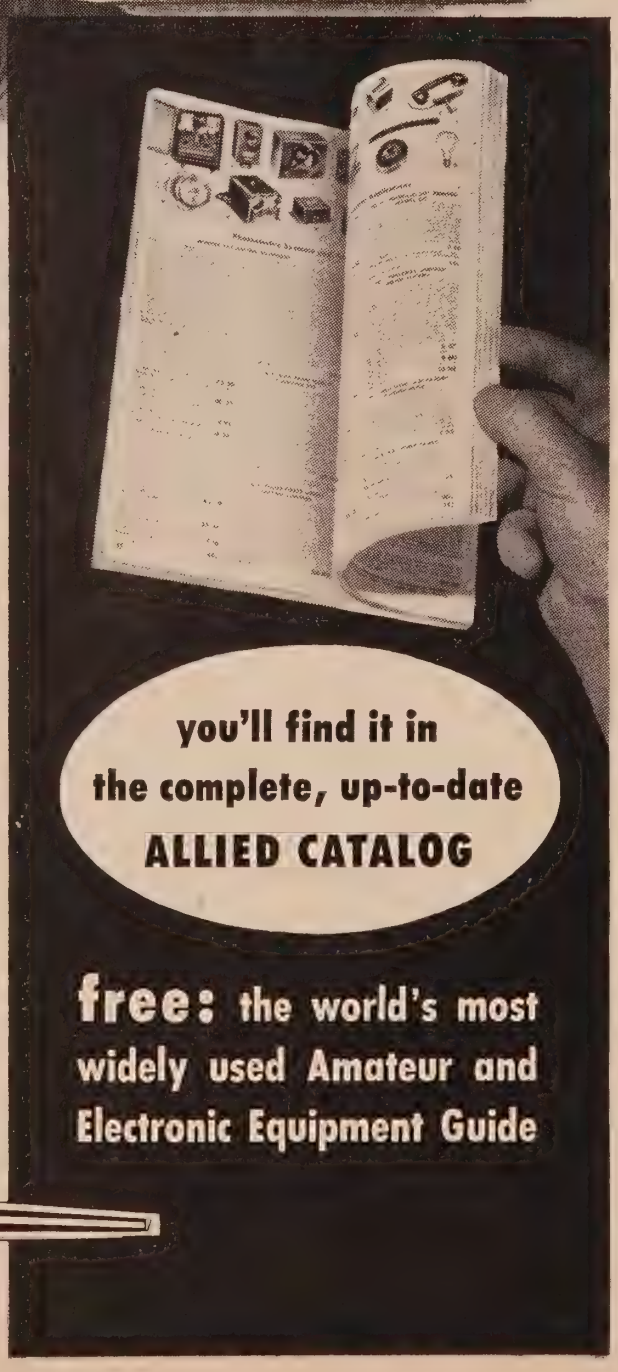

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power plugs as indicated in *Fig. 5-12-E* for a-c power supply operation. The modulator section must also be connected but its gain control should be in the off position. Do not connect *pin 5* of *P3* and of *P4A* at this time. On *P3* remove the jumper between *pins 7* and *8*. Connect the negative end of a milliammeter, having a full scale range of between 5 and 30 Ma., to *pin 7* on *P3*, and the positive side of the meter to *pin 8*, or ground, on the same plug. Place *Sw-1* in up, or "spot" position, and lock up *Rly-1*, with a rubber band or string, so its normally open contacts are now closed. If a 6-volt d-c relay supply is used connected to *P4A* the latter step will not be needed, since the relay will then be energized as *Sw-1* is closed. Place v-f-o bandswitch in 4 Mc. position, and apply power. The VR-150, *V4*, should glow. Measure the potential at *pins 1* and *2*, on *P2*, which should read 150, and about 210 volts respectively.

Listen in on your communications receiver and readjust the slug in *L1* until a signal may be heard from 3.8 to 4 Mc. over the range of the v-f-o tuning capacitor. With the v.f.o. set at 3.9 Mc., readjust the slug in *L5* until the external meter reads 2.5 ma. Check the reading of the meter built into the transmitter. It should indicate a reading at one half scale. If it reads lower, file the carbon resistor, *R8*, at its center until the half scale reading is obtained. The full scale range of the internal meter will then equal 5 ma. This should be again checked by first removing the grid end of *R5*, so the slug in *L5* may be varied to give different values of higher grid current readings for the purpose of checking the two meters with each other. If the initial reading of the internal meter is higher than half scale when the external meter reads 2.5 ma., substitute another resistor at *R8*, as its value may be lower, depending upon its tolerance rating. Then proceed as above.

After the meter is calibrated reconnect *R5* and peak up *L5*. The grid current reading should now be about 2.5 ma. Next, rotate the bandswitch to 14 Mc., and readjust trimmer *C1* until a signal may be heard on the receiver from 14.2 to 14.3 Mc. over about 70 degrees of the dial. Set the v.f.o at 14.25 Mc., and peak up grid current by first tuning *L6* and then *L3*. The grid current should now be above 3 ma., so tune *L3* to the low frequency side of resonance (clockwise) until the grid current drops to 2.5 ma.

Now place the v.f.o. switch in the 28 Mc. position and adjust trimmer *C2* until the signal may be heard from 28.5 to 29.7 Mc. over the range of the dial. Set v.f.o. at 29 Mc., and peak up *L4* and *L7*. Set the v.f.o. at 28.5 Mc., and retune *L7*, but not *L4*. Note the grid current. Repeat the above step with v.f.o. set at 29.7 Mc., and again note the grid current. No less than about 2.5 ma. of current should be realized over the range of the band while retuning *L7*, but not *L4*. If the reading is too low at one end of the band, slightly readjust *L4* until equalization of grid current results over the band.

Remove power and release *Rly-1*. Place *Sw-1* in down, or "XMT" position and lock up *Rly-2* in the same manner as *Rly-1* was previously locked up. Connect a 25- or 40-watt lamp bulb to *P1*. Place the v.f.o. switch at 28 Mc. and set the v.f.o. at about 29 Mc. Place the final amplifier bandswitch at 28 Mc. (clockwise) and rotate the loading capacitor, *C24*, to maximum capacitance. Connect *pin 5* of *P3* to *pin 5* of *P4A*. Apply power, and if at all possible, it is advisable to reduce the plate potential to around 300 volts. Rotate the plate capacitor, *C23*, until resonance is indicated by the minimum current dip of the internal meter. This should occur at about one-quarter scale on *C23*. Rotate *C23* back and forth through resonance, and watch the external grid meter at the same time. It should peak to maximum grid current at the same time as the plate current dips to minimum at resonance. If this does not occur, adjust the neutralizing capacitor, *C18*, until this condition is realized. *Note:* Be sure plate power has been removed when capacitor *C18* is to be adjusted. If it is impossible to obtain neutralization regardless of the setting of *C18*, either reduce or increase the value of *C19*. Neutralization should also be checked on 14 and 4 Mc.

The amplifier may now be checked at full plate potential. Adjust the loading by *C24* and retune to resonance with *C23* until the internal meter reads a little less than three quarters of full scale at resonance. The lamp bulb should light indicating the r-f power into the load. Now remove power and disconnect the external grid meter. Connect *pin 7* of *P3* to *pin 8* on the same plug. Connect the positive side of a milliammeter having a full scale range of at least 100 ma., to *pin 5* of *P4A*, and the negative side to *pin 5* of *P3*. The existing lead between these two points will have to first be disconnected. Again apply power and check the reading of the built-in meter with that of the external meter, both of which will be reading the sum of the screen and plate currents (the grid current also is included in the reading of the internal meter but it may be discounted on this range). If the meters do not read alike (the full scale range of the internal meter should be considered as 100 ma.), the value of *R10* will have to be altered accordingly. Decreasing *R10* will increase the meter reading, and vice-versa. Remove the external meter and restore the normal *pin 5* connections. With 500 volts the correct loading is at a current of 70 to 75 ma. as indicated by the meter. Under normal operation the grid current should read between 2

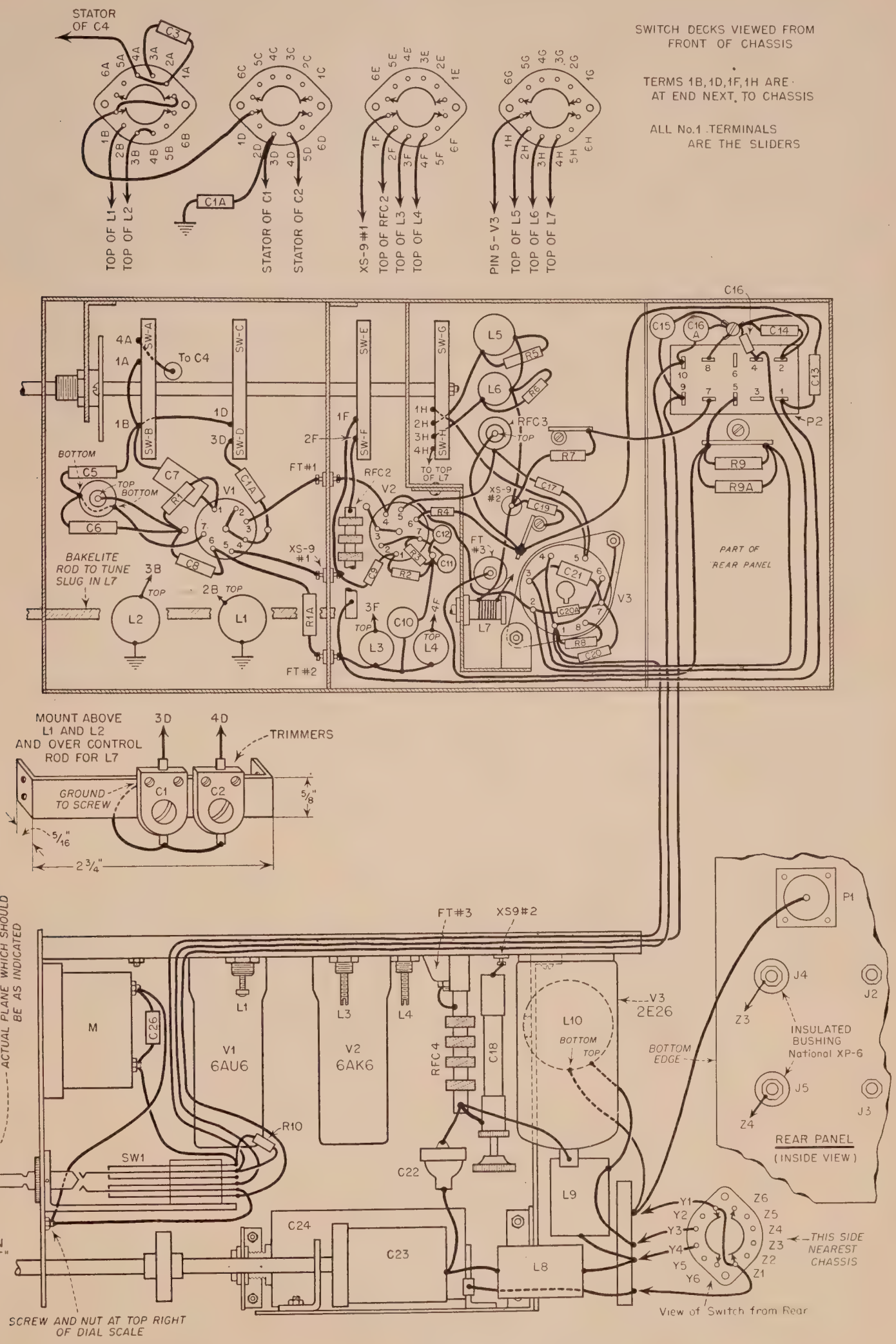

Fig. 5-12-H. Pictorial wiring diagram.

Coil Data — Modified Version

80-40-20 Meter Operation

Ca—80 μμfd., ceramic, four Centralab TCZ-20 in parallel.
L4a—(3.6 Mc.) 120 turns #32 enam. on Millen #69045 copper slug form.
L7a—(7.2 Mc.) 70 turns #28 enam. on Millen #69045 copper slug form.
L8a—(14 Mc.) 2¾" of B&W #3010 Miniductor.
L9a—(7.2 Mc.) 1⅝" of B&W #3007 Miniductor.
L10a—(3.8 Mc.) 2" of B&W #3015 Miniductor.
Ra—10,000 ohms, ½w.

80-40-15 Meter Operation

L6b—(21 Mc.) 22 turns #24 enam. on Millen #69048 iron slug form.
L8b—(21 Mc.) 2" of B&W #3006 Miniductor.
L9b and L10b are the same as L9a and L10a.

and 2.5 ma. when *Sw-1* is in the "spot" position. On 28 Mc. this must be set by the panel control of *L7*. Where the current is higher than 2.5 ma., *L7* should be detuned to the high frequency side of resonance (counterclockwise).

Modulation should preferably be checked by means of an oscilloscope; however, observations of the lamp bulb load will provide an indication of modulation. With maximum modulation at the point at which there is no clipping the lamp bulb will brighten moderately with speech input to the audio system. With clipping the brilliance of the lamp will increase considerably.

After all the above adjustments and tests are completed give all the inductors in the v.f.o. and buffer-doubler section a coat of polystyrene cement, or equivalent. Then install the sides and top piece of the r-f unit and calibrate the v.f.o. since it will have slightly been shifted by the installation of the side and top. Secure screw of *L1* slug with glyptal or duco cement.

Installation

When the installation is made in the car using a 6-volt battery source the connections should be made as shown for *P4*. At least No. 12 size wire should be used for the 6-volt heater leads, which includes the ground leads. Shock proof mounting of the model was not found necessary to maintain stability, but nevertheless, this step would be a wise precaution. As previously mentioned on 14 and 4 mc. correct loading may not be obtainable over the range of *C24*, so padding capacitors may be inserted in the banana jacks provided for this purpose. In the author's installation an additional 200 μμfd. is required for 14 Mc. and 400 μμfd. is needed for 4 Mc.

In some instances it may be desirable to make certain modifications. If a 300- or 400-volt supply is to be used *R22* must be decreased until the potential at the screen of *V6* measures 225 to 250 volts, and *R12* must be decreased until the potential at *pin 2* of *P3* is approximately 200 volts. Tube *V4* should still glow after this change.

Resistor *R23* will also have to be decreased, and this should be done while using a 'scope to check the modulation. With 400 volts the final amplifier loading should be adjusted to where the meter reads 65 to 70 ma., and with 300 volts, the reading should be 60 ma. Apply tone modulation and reduce the size of *R23* until the maximum modulation level is just under 100%. When 300 volts is used the OZ4 negative peak clipper may not fire, in which case it will be necessary to short out this tube.

A carbon microphone may be used by disconnecting *R16* at the point marked X, *Fig. 5-12-E*, and then connecting the secondary of the microphone transformer between the top of *R16* and ground. The ground end of *R21* should be opened up and returned to ground through the microphone and the transformer primary in series. A 4 to 8 μfd. capacitor should also be connected from the bottom of *R21* to ground. This circuit might be omitted and the microphone current obtained from two flashlight cells.

If it is desired to use the 6146 in place of the 2E26 tube in the p.a. stage the *V3* clearance hole must be made larger to provide clearance, and a different supporting arrangement will

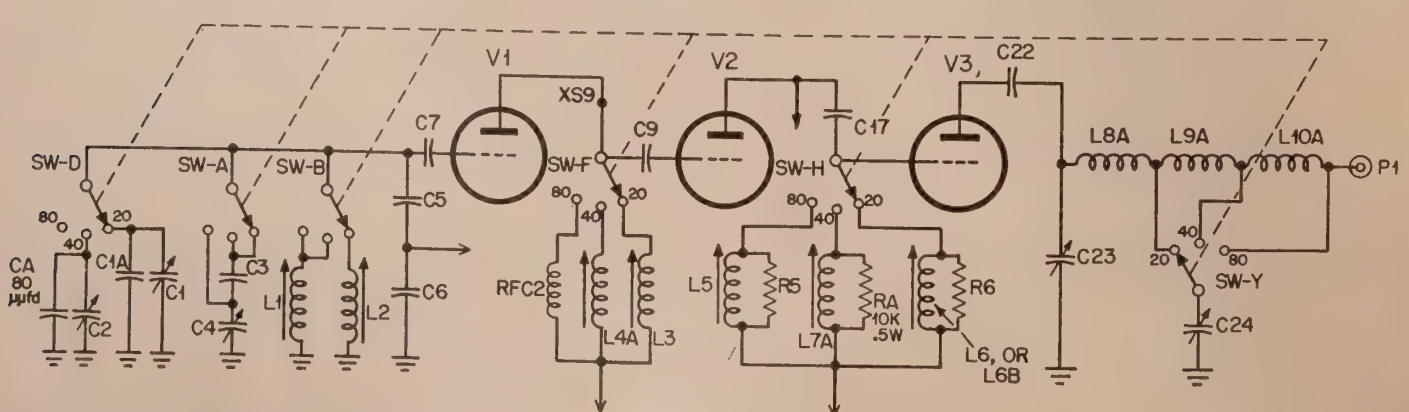

Fig. 5-12-J. Wiring changes to the switch points for 40 and 15-meter band coverage.

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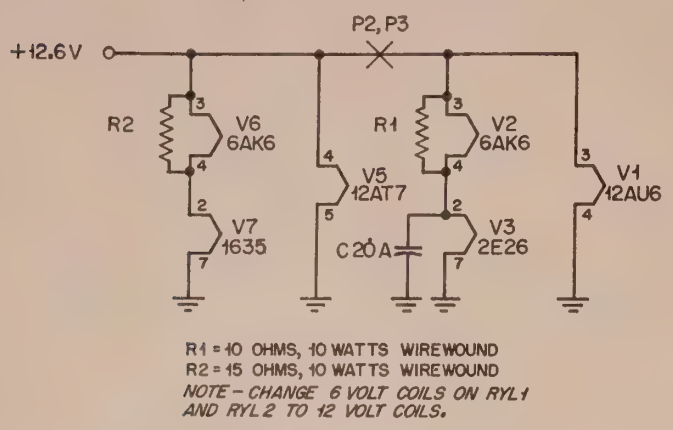

Fig. 5-12-K. Filament wiring modification for operation from a 12-volt supply.

be necessary for the *V3* socket. At 500 volts an input of 50 watts is permissible with the 6146. Resistor *R8* will have to be doubled to make the full range scale of the meter equal to 200 ma. in transmit position.

40 and 15 Meter Operation

The original "Mobile Special" was designed to operate on the 80-, 20- and 10-meter phone bands. If the 10-meter band is omitted other coils for either 40 or 15 meter operation may be substituted. The following information is referred to in *Fig. 5-12-E* and the *Coil Data Table*.

If 40 meter operation is desired all connections in *Fig. 5-12-E* that go to the 20-meter taps of switch *Sw-A/Sw-Z* are moved over to the 10-meter tap points. The blank 20-meter taps are now used for the 40-meter connections. The switch positions will now read "80-40-20" instead of "80-20-10". *Figure 5-12-J* illustrates the wiring changes to the switch points and the new coil information for 40-meter operation.

The oscillator circuit of the 6AU6 tunes from 1.8 Mc. to 1.825 Mc. for 40-meter operation. Coil *L1* (the 80-meter coil) is used to cover this range, padded by *C2* and *CA* to the correct range. The plate circuit of the 6AU6 is broadly tuned to 80 meters by *L4A*. The 6AK6 is used as a doubler to 40 meters, tuned by *L7A*. It is necessary to load *L7A* with a resistor *RA* to limit excitation to the 2E26 stage.

The highest frequency the 2E26 stage now tunes to is 20 meters, so it is necessary for *L8A* to resonate on 20 meters, *L8A* plus *L9A* to resonate on 40 meters, and *L8A* plus *L9A* plus *L10A* to resonate on 80 meters.

15-Meter Operation

Again, for 15-meter operation as for 40-meter operation, the 10-meter coils are omitted. Since the 20- and 15-meter bands are very similar as to skip, it was decided to modify the transmitter for operation on 80, 40 and 15 meters. The 40-meter modifications are made as described above. For 15-meter operation the 6AK6 operates as a tripler from 7 Mc. to 21 Mc. Although the plate circuit of the 6AU6 is tuned to 14 Mc. by coil *L3*, sufficient 7-Mc energy appears at the grid of the 6AK6 to enable it to triple to 21 Mc. with good efficiency. Coil *L6B* is tuned to 21 Mc. in the plate circuit of the 6AK6. The plate circuit of the 2E26 is resonated to 21 Mc. by means of coil *L8B*, *L8B* plus *L9A* still resonate to 40 meters, and *L8B* plus *L9A* plus *L10A* resonate to 80 meters.

12-Volt Operation

Some of the newer cars are equipptd with a twelve-volt ignition system. The "Special" may be suitably modified as shown in *Fig. 5-12-K* to work from a 12-volt supply. A 12AU6 is substituted for the 6AU6 oscillator. The 6AK6 has no 12-volt equivalent, nor does the 2E26. These two tubes have their filaments connected in series across the 12-volt line, with *R1* acting as a current shunt for the 6AK6 tube.

In the modulator the 12AT7 filament is rewired for 12-volt operation, and the 6AK6 and 1635 filaments are connected in series across the 12-volt line. *R2* acts as a current shunt for the 6AK6 tube. Relays *Rly1* and *Rly2* should have 12-volt coils substituted for the 6-volt coils. No other circuit changes need be made.

5.13—Mobile Conversion of the SCR-274N Command Equipment

The *SCR-274N* series equipment makes an excellent foundation for mobile conversions. It is light, ruggedly built and so constructed as to make modification a relatively simple matter. The following information is divided into two parts: (1). Conversion and modernization of the basic equipment for 80 and 40-meter operation, and (2). Conversion and modernization of the circuitry for 20, 15 and 10-meter operation.

The Original Equipment

The complete SCR-274N set makes up a multi-channel transmitting and receiving station for aircraft equipped with a 24-volt d-c power supply. It will receive signals over the range of 550 kc. to 9.0 Mc. It will transmit A1, A2, or A3 signals over the range of 2.1 to 9.1 Mc. Identical items of receiving equipment have various nomenclatures, as follows:

JAN Number	Navy Number	Army Number	Frequency Range	I.F.
- - -	46129	BC-453	190-550 kc.	85 kc.
- - -	46145	BC-946	520-1500 kc.	239 kc.
- - -	46104	- - -	1.5-3.0 Mc.	705 kc.
R-26/ARC-5	46105	BC-454	3.0-6.0 Mc.	1415 kc.
R-27/ARC-5	46106	BC-455	6.0-9.0 Mc.	2830 kc.

The JAN receivers differ slightly from the Army and Navy versions in that they have a.v.c., and employ a 12SF7 as the second i-f tube, rather than a 12SK7. They also have different connector plugs. A typical Command receiver circuit applicable to all models is shown in *Fig. 5-13-A*. Top and bottom views of a typical receiver with some parts indicated by Armed Service nomenclature are shown in *Fig. 5-13-B* and *5-13-C*.

Physically, all the receivers are almost identical. The tuned circuits, the i-f transformers,

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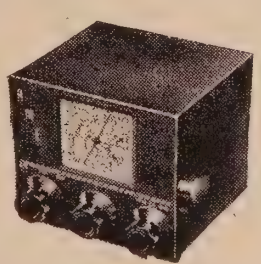

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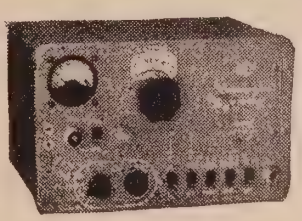

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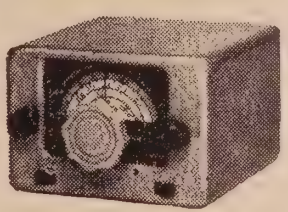

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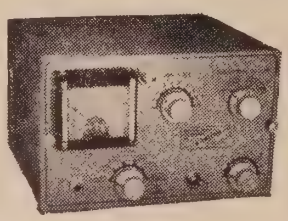

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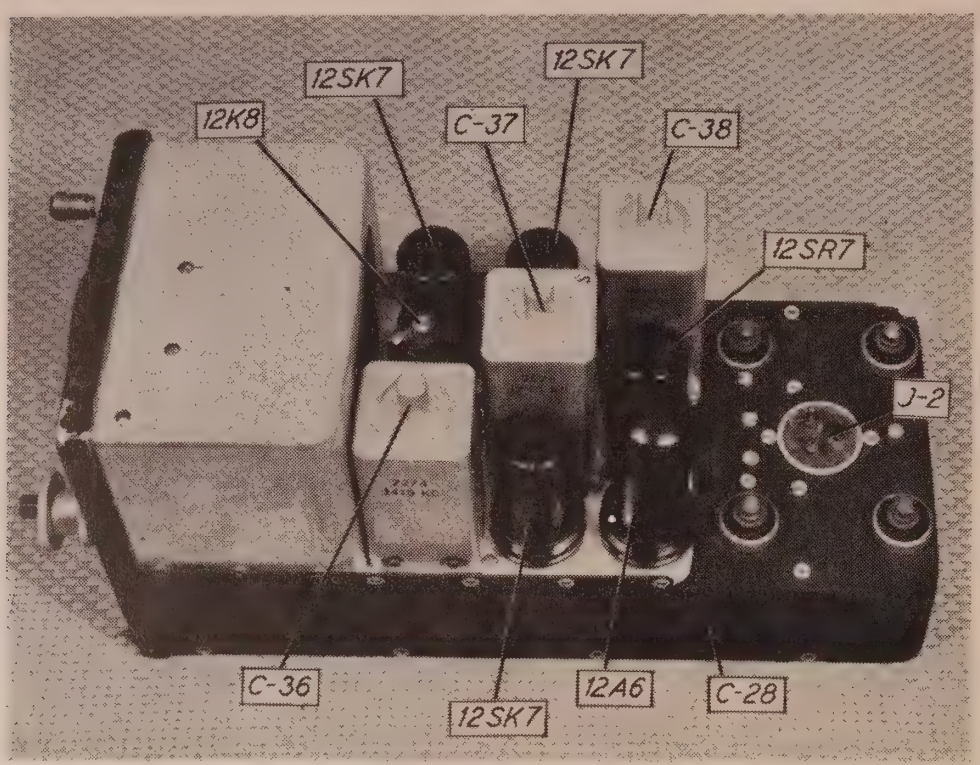

Fig. 5-13-B. Top view of a typical receiver. A bottom view of this receiver is shown on page 172.

and the padding condensers differentiate one from the other. By changing these components, for example, a *BC-453* may be made into a *BC-946*.

The two high frequency receivers that cover 80 and 40 meters are not recommended for general mobile operation. Their i.f. channels are too high and as a result the receivers tune too broadly for effective mobile operation. They are, however, useful as standby or interim equipment, and if they can be purchased cheaply enough make a very satisfactory secondary receiver.

The low frequency (200-550 kc.) and intermediate frequency (520-1500 kc.) receivers make very satisfactory i.f. strips for mobile converters. The receivers have high sensitivity and a very good order of i.f. selectivity. The selectivity curves for all receivers are shown in *Fig. 5-13-D*.

Six Volt Conversion of the Receivers

To rework the receivers for six-volt operation is relatively simple. The filament circuit must be rewired as shown in *Fig. 5-13-E* which places all the tube heaters in parallel. The tubes should then be replaced with their six-volt equivalents. The 12A6 has no exact six-volt equivalent, but a 6K6 or 6V6 will work well as a substitute. The 12SF7 tube in the ARC-5 series receivers until recently had no six-volt counterpart, but the 6SF7 is now available.

If desired, the filament choke, *L-14*, may be removed from the receiver as it is of no use.

A small control panel should be made to fill the gap left by the removal of the switch panel adapter plate on the front of the receiver. This panel should contain a volume control, a b-f-o switch and a speaker jack. The panel may be wired as shown in *Fig. 5-13-F*, and then bolted

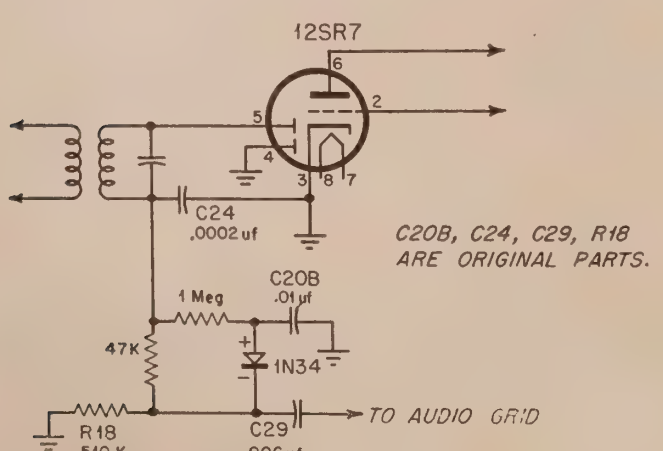

Fig. 5-13-G. This simple but effective noise limiter may be left in the circuit at all times.

Fig. 5-13-A. Basic receiver circuit schematic (see page 170) and parts list. With the exception of the coils, this is the circuit of all of the war surplus 274N series receivers.

C-1—11 μμfd.
C-2—15 μμfd.
C-3, C26—100 μμfd.
C-4 (A to G)—147 μμfd., variables
C-5—3.0 μfd.
C-6 (A to C)—0.05 μfd.
C-7 (A to C)—0.05 μfd.
C-8, C24—100 μμfd.
C-9—40 μμfd.
C-10—365 μμfd.
C-11—3 μμfd.
C-12, C-14, C-17, C-19, C-22, C-23, C-27—180 μμfd.
C-13, C-18, C-21—17 μμfd.
C-15 (A to C)—0.05 μfd.
C-16 (A to C)—0.22 μfd.
C-20 (A, B, C)—0.05/0.01/0.05 μfd.
C25, C31—0.001 μfd.
C-28—34 μμfd.
C-29—0.006 μfd.
C-30—15 μfd.
C-32—5.0 μfd.
C-33—wiring capacity.
C-36, C-37, C-38—17 μμfd.
L-14—choke, 112 uh.
L-15—choke, 3.0 h.
R-1, R-4, R-9—620 ohms.
R-2, R-20—2.0 megohm.
R-3, R-16, R-17—51,000 ohms.
R-5—150,000 ohms.
R-6—200,000 ohms.
R-7, R-8, R-13—200 ohms.
R10—360,000 ohms.
R-11, R-14—100,000 ohms.
R-12—510 ohms.
R-15—5100 ohms.
R-18—510,000 ohms.
R-21—1500 ohms.
R-22, R-23—7000 ohms.

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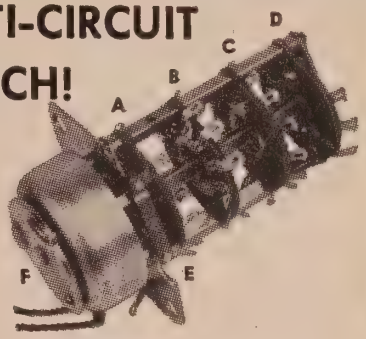

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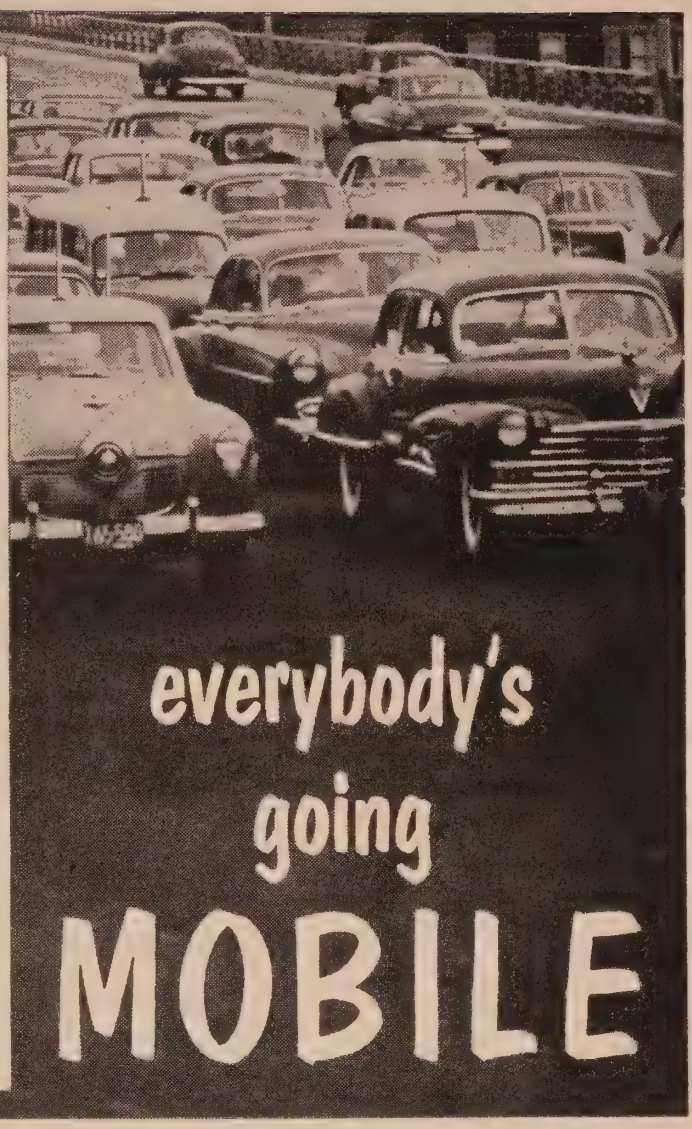

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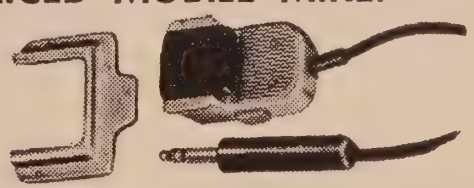

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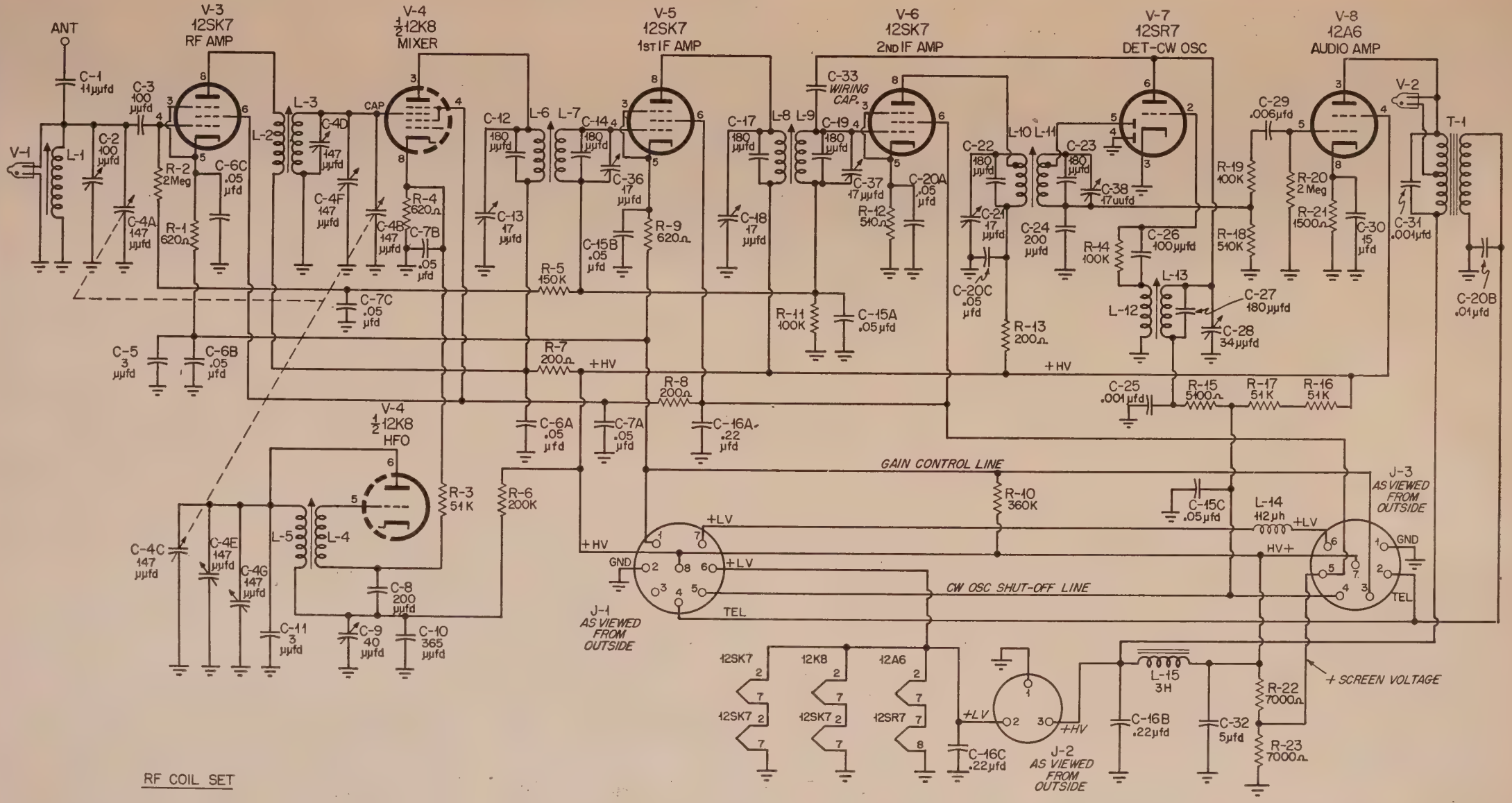
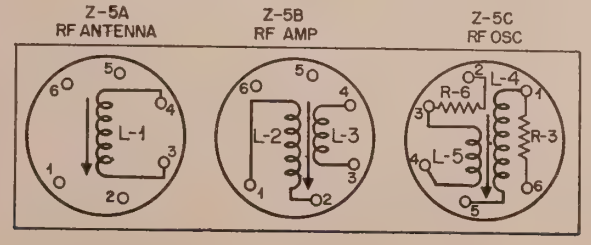
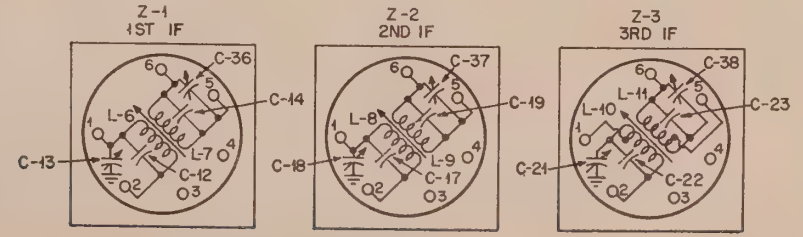
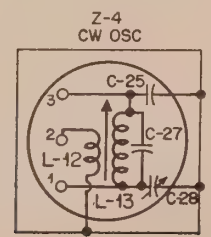
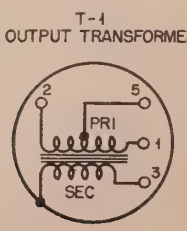

ANT
V-1
V-3
12SK7
RF AMP
V-4
½12K8
MIXER
V-5
12SK7
1ST IF AMP
V-6
12SK7
2ND IF AMP
V-7
12SR7
DET-CW OSC
V-8
12A6
AUDIO AMP
V-2
T-1
V-4
½12K8
HFO
C-33 WIRING CAP.
GAIN CONTROL LINE
CW OSC SHUT-OFF LINE
+HV
+LV
HV+
GND
TEL
J-1 AS VIEWED FROM OUTSIDE
J-2 AS VIEWED FROM OUTSIDE
J-3 AS VIEWED FROM OUTSIDE
+ SCREEN VOLTAGE
12SK7
12K8
12A6
12SR7

RF COIL SET


Z-5A
RF ANTENNA
Z-5B
RF AMP
Z-5C
RF OSC
L-1
L-2
L-3
L-4
L-5
R-6
R-3


Z-1
1ST IF
Z-2
2ND IF
Z-3
3RD IF
C-36
C-14
C-13
C-37
C-19
C-18
C-38
C-23
C-21


Z-4
CW OSC
C-25
C-27
L-12
L-13
C-28


T-1
OUTPUT TRANSFORMER
PRI
SEC

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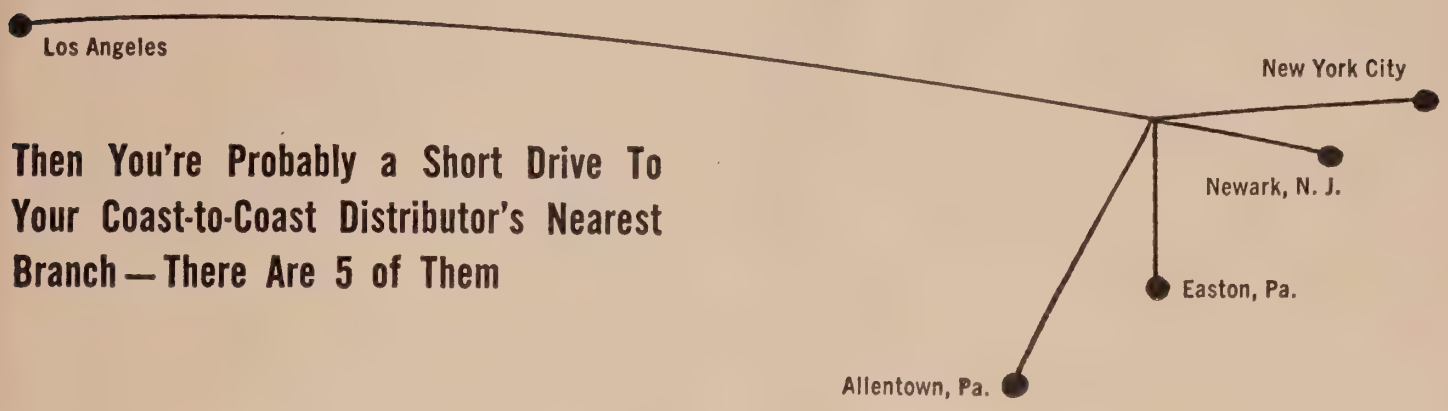

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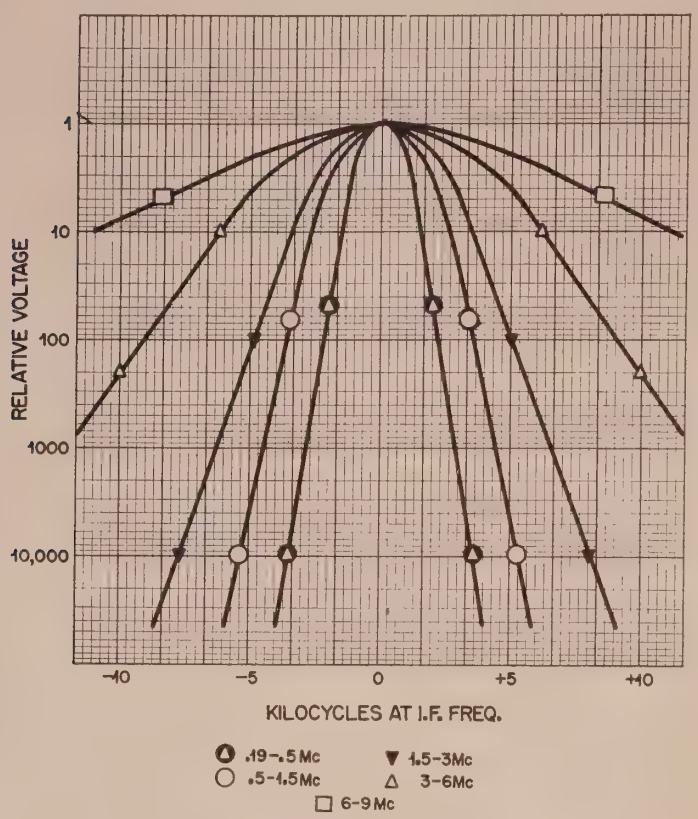

Fig. 5-13-D. Selectivity curves for the Command receivers.

to the front panel of the receiver. The leads from this panel are soldered to the jacks in *J-1*.

A very satisfactory tuning dial for the receiver may be made from a short length of ¼" inside diameter copper tubing. Slot the tubing on both ends and use it as a coupling between the splined tuning shaft and a short length of ¼" rod to which a tuning knob is attached. Fill the sleeve with duco cement or nail polish before fitting it over the splined shaft of the receiver. It will withstand rough usage.

A simple noise limiter circuit may be added to the Command receivers *(Fig. 5-13-G)*. It may be left connected permanently in the circuit and no additional controls are needed for it.

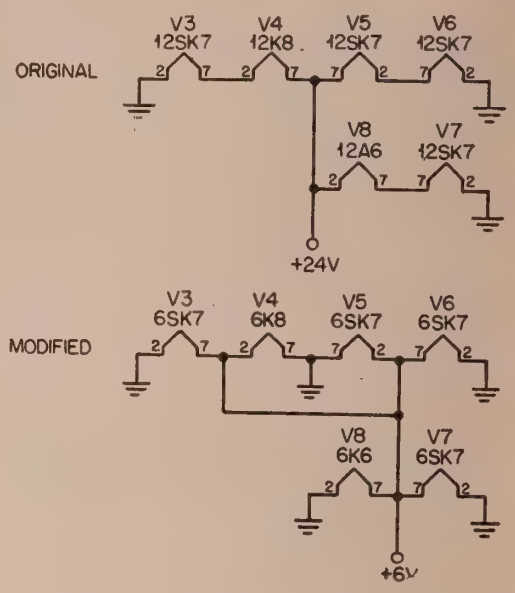

Fig. 5-13-E. Filament rewiring schematic for conversion to operate from a 6-volt source.

Conversion of the 3.0-6.0 Mc. Receiver for Operation on 20, 15 and 10 Meters

The "80 meter" Command receiver will make a sensitive receiver for the high frequency bands. It is an excellent performer, even though the i.f. selectivity leaves quite a lot to be desired. The conversions for the various bands are much the same, and consist of boosting the gain of the receiver and winding new r.f coils to cover the proper ranges.

1. To boost the gain sufficiently for 20 and 15-meter operation, it is necessary to replace the 6SK7 i-f tubes with 6SG7 tubes. A 6SG7 tube should also be used in the r-f stage. No circuit changes are needed. For 10-meter operation, a 6AC7 or (better still) a war-surplus 717A tube should be used in the first r-f stage.

   The socket connections for the 717A tube are the same as for the 6SK7. To

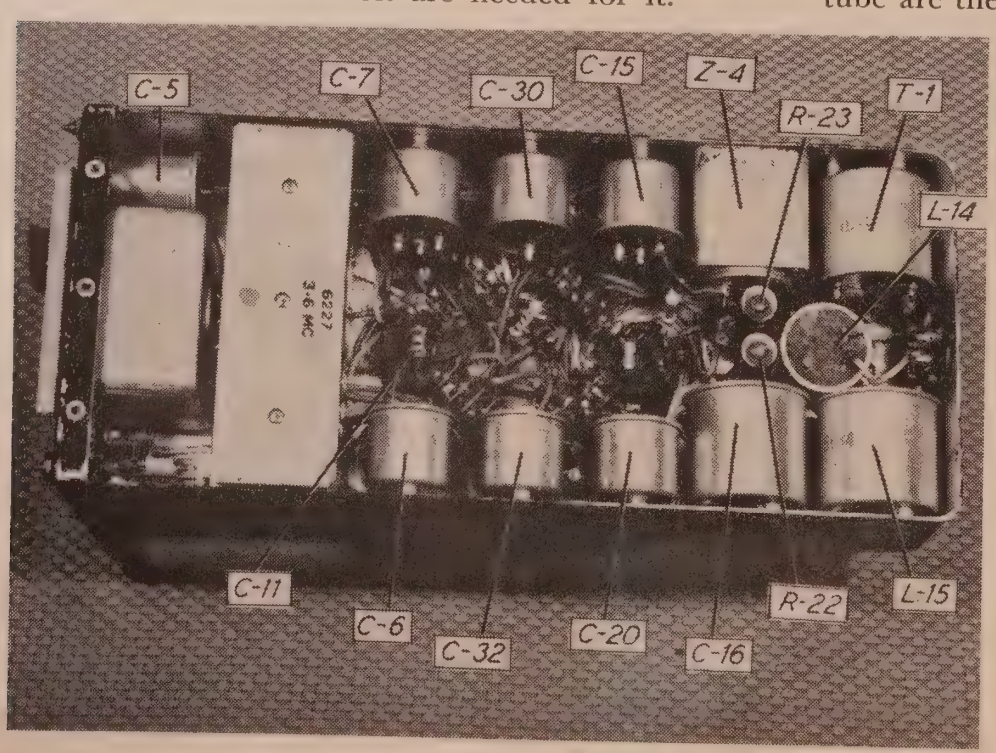

Fig. 5-13-C. Bottom view of a typical 274N series receiver. The nomenclature corresponds with that employed by the Armed Services in their Tech Manuals.

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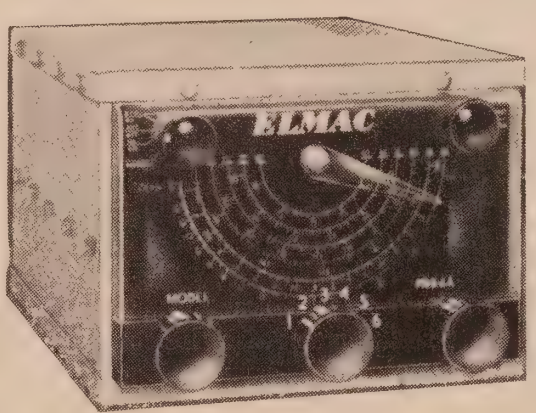
6AG5—Multiplier
6AG5—Crystal Osc.
6AU6—VFO
OA2—VR Tube (not furnished)
6AU6—1st S.A. in A54H
6C4—1st S.A. in A-54
12AU7—Phase Inverter
2-6L6GA—Modulators

Portable Mobile Receiver—6 Bands A (AMATEUR COVERAGE)

- 6 Bands
  - (1) 600 kc to 2000 kc. (Broadcast and 160 meter band)
  - (2) 3.5 to 4.0 Mc. (75 and 80 meter band)
  - (3) 6.9 to 7.4 Mc. (40 meters)
  - (4) 13.95 to 14.45 Mc. (20 meters)
  - (5) 20.95 to 21.65 Mc. (15 meters)
  - (6) 28 to 29.7 Mc. (10 meters)
- Dual-Conversion eliminates images. 1600 kc first I.F. 455 kc second I.F.
- Built-in highly effective noise limiter.
- Built-in Beat Frequency Oscillator.
- Tuned R.F. ahead of converter on all bands.
- Voltage regulated to local oscillator, BFO, and second converter.
- Antenna input designed to match 50 ohm coax.
- Power requirements: 6 volts A.C. or D.C. at 3.3 amperes. 250 volts D.C. at 90 milliamperes.

Power supplies available for 6 and 12V. D.C. or 115V. A.C.

- Cabinet finished in grey hammertone size 4½" H. x 6" W. x 8½" Deep. Weight: 6½ pounds.



- Uses 10 tubes.
  - 1—6BJ6 R.F. Amplifier
  - 1—6BE6 First Converter
  - 1—6C4 Local Oscillator
  - 1—6BE6 Second Converter
  - 2—6BJ6 First and Second I.F. Amplifier
  - 1—6AL5 Detector and Noise Limiter.
  - 1—12AT7 First Audio and B.F.O.
  - 1—6BK5 Audio Output
  - 1—OB2 Voltage Regulator
- **Price: $134.50**

Fort Orange RADIO DISTRIBUTING COMPANY

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TELEPHONE ALBANY 5-1594

Coil Winding Data (Table 5-13-A)

10 Meters

R.f. Stage (L1)—6 turns #18 enam. space wound to length of coil. Antenna coil has 2 turns to pins 1 & 6.

Mixer Stage (L2 & L3)—9 turns of original wire interwound with L3. L3 has 5 turns #18 enam. wound length of coil.

Oscillator (L4 & L5)—5 turns #18 enam. close wound, 1/8" from L4. L4 is unchanged. The oscillator tuning range for a 1415-kc i.f. is 29,415 to 31,115 kc.

15 Meters

R.f. Stage (L1)—8 turns #18 enam. space wound to length of coil. Antenna coil has 3 turns to pins 1 & 6.

Mixer Stage (L2 & L3)—13 turns of original wire interwound with L3. L3 has 8 turns #18 enam. wound length of coil.

Oscillator (L4 & L5)—7 turns #18 enam. close wound 1/8" from L4. L4 is unchanged. The oscillator tuning range for a 1415-kc i.f. is 22,415 to 22,865 kc.

20 Meters

R.f. Stage (L1)—11 turns #18 enam. space wound to length of coil. Antenna coil has 4 turns to pins 1 & 6.

Mixer Stage (L2 & L3)—18 turns of original wire interwound with L3. L3 has 11 turns #18 enam. wound length of coil.

Oscillator (L4 & L5)—10 turns #18 enam. close wound 1/8" from L4. L4 is unchanged. The oscillator tuning range for a 1415-kc i.f. is 15,415 to 15,765 kc.

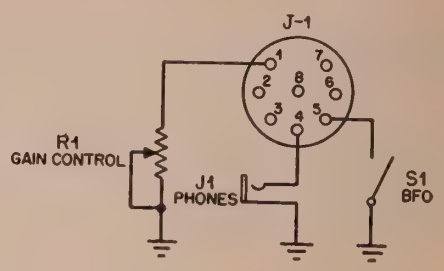
use these high gain tubes at 10 meters, a few circuit alterations must be made:

A—Shunt a 620-ohm, ¼ watt resistor across cathode resistor *R-1*.

B—Bypass *pins 3, 5* and *6* of the r-f tube socket to ground with .001 μμfd. Ceramicons *(Erie 801-001)*. Use short leads.

C—Shunt *R-22* with a 10,000-ohm, 10-watt resistor to raise the screen voltage to about 140 volts.

2. If it is desired to use a coaxial line input to the receiver, the present antenna terminal should be removed and an *Amphenol 83-1R* coaxial fitting substituted in its place. Run a short length of small coaxial line from the fitting to *terminals 1* and *6* of the r-f coil socket. Tie the shield to *terminal 6* and also to *terminal 3*. This will ground the shield. Antenna windings should be added to the r-f coils as shown in *Table 5-13-A*.
3. Remove all but one rotor plate in each section of the tuning condenser. The plate that is left should be the slotted one, for alignment adjustments. These extra plates may be easily removed by flexing them gently with a pair of long nosed pliers.



J1-SINGLE CIRCUIT JACK, ICA*1870
R1-50000 Ω CENTRALAB B-31
S1-SPST SWITCH, ICA*1230

Fig. 5-13-F. This diagram shows the necessary components needed in the small switch plate box on the front of the typical 274N receiver.

When the receiver modifications have been made, the coils should be modified as shown in *Table 5-13-A*. Remove the plug-in coil unit from the bottom of the receiver, noting that it is polarized by the pin arrangement of the three coils. Remove the coils from the shield can, one at a time, and remove the cores from the coils. The cores should be replaced after the coil modifications have been made. Core position is not critical. When the coils have been modified they should be replaced in their respective shields, the leads soldered and the coil unit placed back in the receiver. Turn on the receiver, and hunt for the signal from the h.f. oscillator of the command set in the station receiver. It should fall within the ranges indicated in *Table 5-13-A*. Adjust the trimming and padding condensers *C-4* and *C-9* to give the proper bandspread. Do not disturb the wiring between the 6K8 and the oscillator socket. These leades are cemented in place and should not be moved or the calibration of the receiver will shift. Tracking may be improved by bending the slotted rotor plate of the oscillator condenser. It is possible, by proper adjustment, to employ the original dial lines with new figures for the new ranges.

When the mixer and r-f coils have been rewound, trimmers *C-2, C-4F* and *C-4D* should be adjusted to bring in signals when a short length of wire is used for an antenna. Slight adjustment of coil turns spacing and adjustment of the slotted rotor plates may be in order to secure closed tracking of these two stages.

When this is completed, the tuning gang cover should be replaced, and the coil set bolted into place. Retouch the r.f. alignment of the receiver, and the conversion is complete.

The Command Transmitters

JAN Number	Navy Number	Army Number	Frequency Range	Xtal Check
T-18/ARC-5	52232	- - - -	2.1-3.0 Mc.	2.5 Mc.
T-19/ARC-5	52208	BC-696	3.0-4.0 Mc.	3.5 Mc.
T-20/ARC-5	52209	BC-457	4.0-5.3 Mc.	4.6 Mc.
T-21/ARC-5	52210	BC-458	5.3-7.0 Mc.	6.2 Mc.
T-22/ARC-5	52211	BC-459	7.0-9.1 Mc.	8.0 Mc.

These v-f-o transmitters are all similar physically, only the tuning inductances and crystals are changed for each band. The JAN series transmitters differ slightly from the Army and

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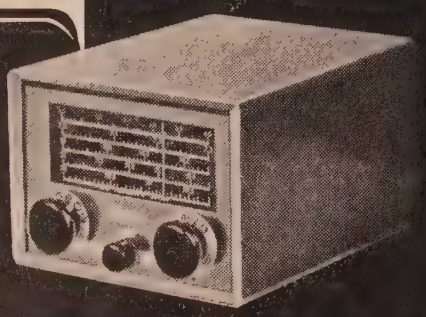

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THE MORROW 5BR HAS NO EQUAL! *Compare these features:*

FOR OPERATING EASE—5 BANDS on 5 easy to read, accurately calibrated slide rule scales; 3.5—4.0 Mc, 7.0—7.3 Mc, 14.0—14.35 Mc, 21.0—21.45 Mc, and 28.0—28.7 Mc. TEMPERATURE COMPENSATED CLAPP OSCILLATOR assures low drift performance. Each Osc. coil is slug-tuned for calibration accuracy. Car generator voltage fluctuations will not affect stability. SINGLE POINT TUNING with high image rejection, negligible birdies or BC break-thru. BETTER THAN ½ MICROVOLT SENSITIVITY by using Polystyrene coil forms. Zero-temp ceramic trimmers on all Ant., Osc. and Mixer circuits. AVC on preselector, NO BLOCKING ON STRONG SIGNALS. IF Amp with 4 tuned circuits. 1525 Kc output. A VERY EFFECTIVE NOISE LIMITER. ANTENNA TRIMMER on front panel. Tube complement: 6CB6 RF Amp., 12AT7 Mxr & Osc., 6BA6 IF Amp. and 6AL5 Noise Lmtr. STRONG CASE finished in lustrous Hammer-Tone. Complete with hardware and instructions. H: 4 in. W: 5 5/8 in. D: 6 5/8 in. For 6 or 12 volt operation. Yes . . . THE 5BR SATISFIES THE MOST CRITICAL OPERATOR.

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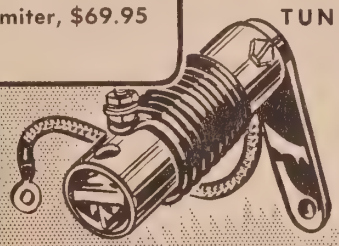

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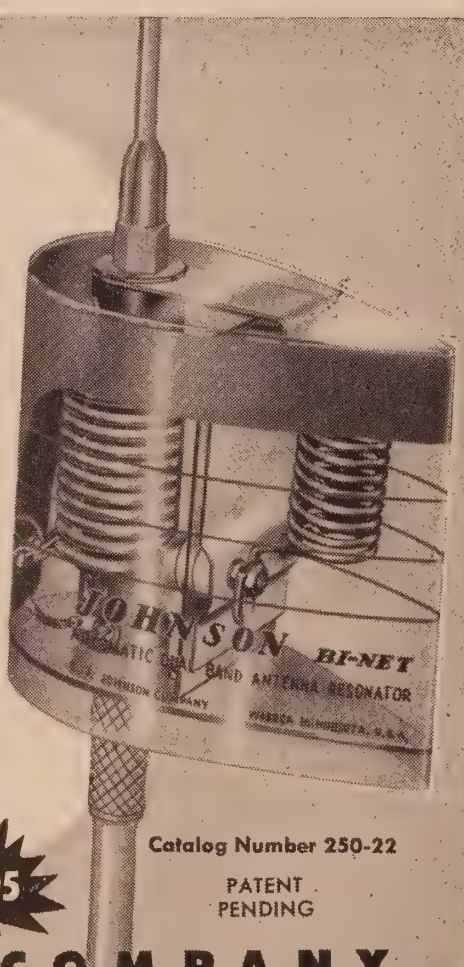

Dual mobile antenna loading network for 10 and 20 meter amateur bands. Mounted in the center of a standard mobile whip antenna, it enables the operator to change bands *while in motion*. Operation is completely automatic, no relays nor mechanical control required. After initial adjustment, the BI-NET requires no further attention. Now, for the first time, true bandswitching mobile operation is attainable.

The BI-NET is a tuning network consisting of two adjustable, low-loss inductors and a ceramic insulated fixed capacitor. Inductors are silver plated for maximum conductivity. The assembly is enclosed in a streamlined, weatherproof plastic housing and is equipped with ⅜" x 24 female threads at each end for antenna mounting. Overall size, 4-7/16" high, 5-5/16" long, 2 ⅜" maximum width, weight 14 oz.

AMATEUR NET

$10.95

Catalog Number 250-22

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E. F. JOHNSON COMPANY

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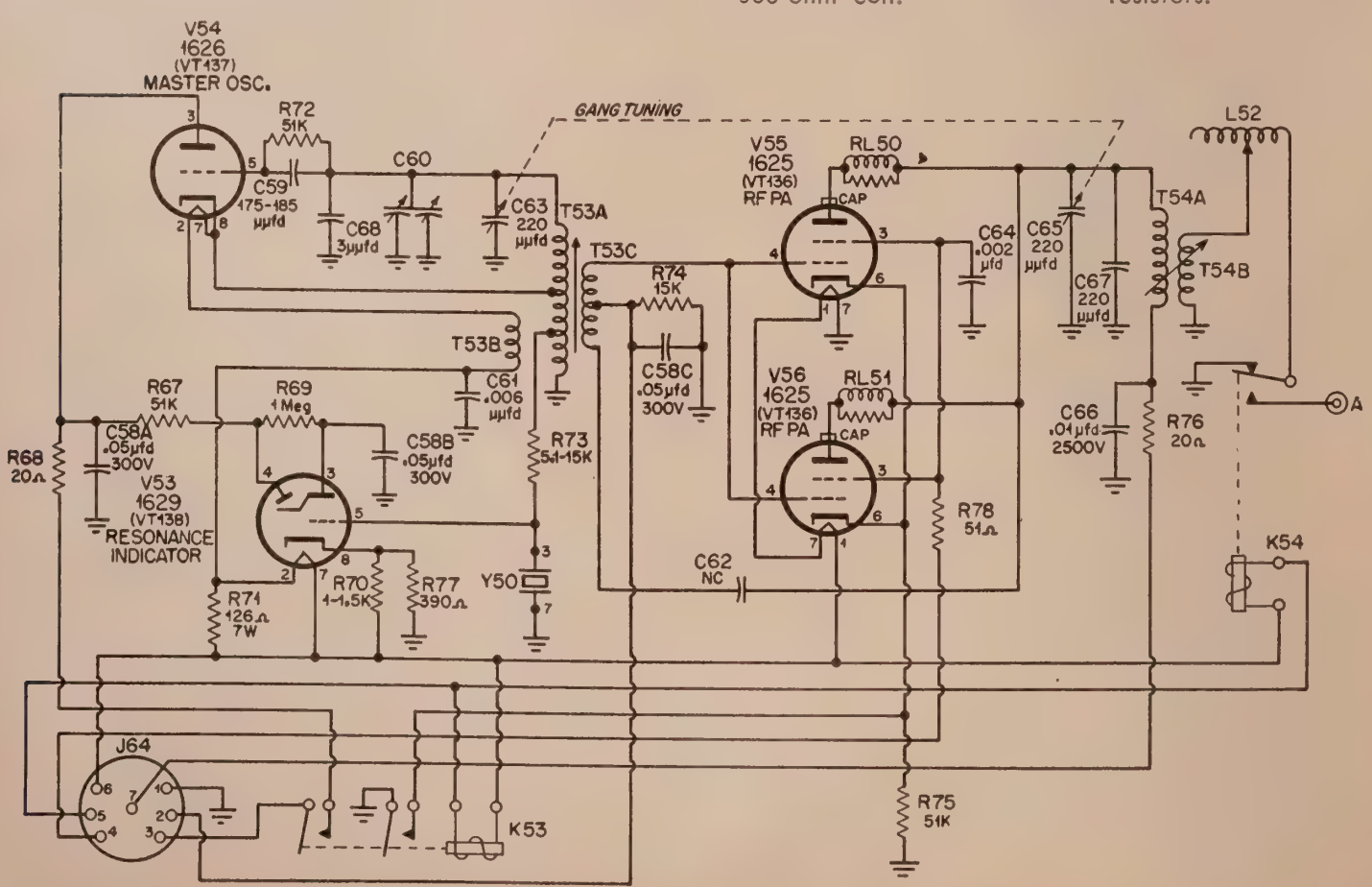
Navy versions in that they have shunt feed in the power amplifier stage and different power receptacles that will not match the standard SCR-274N racks. Because of the shunt fed circuit, the ARC-5 transmitters may be plate modulated at a potential of 700 volts or so, with no danger of flashover. A typical transmitter circuit applicable to all models is shown in *Fig. 5-13-I*. A bottom view of a Command transmitter with standard Armed Services nomenclature is shown in *Fig. 5-13-H*.

For six-volt operation, all transmitter tubes must be changed, and relays *K-53* and *K-54* removed. The filament circuits must be changed from series connection to parallel connection. Since the electron eye indicator is rarely used in amateur operation, it may be removed completely along with the calibrating crystals, thus simplifying the conversion. The complete conversion, including TVI measures, calls for replacement of all by-pass condensers, and the shortening of ground return leads. One of the basic faults with the original transmitters is the faulty grounding and bypassing caused by long ground leads and inductive condensers. While the conversion to six volts is being done, it is very little additional work to modernize the circuits, and clean up the TVI and parasitic problems. The revised schematic, applying to units intended to work in the 80 and 40 meter bands, is shown in *Fig. 5-13-J*. The conversion steps are:

1. Remove the 1629 electron eye socket and the resistors mounted on it. Remove resistor *R-71* mounted above the socket. Remove the crystal calibrator socket and its associated resistors. Take out *C-57* (see *Fig. 5-13-H*) and all the small components beneath the chassis except the neutralizing condenser, *C-62*, and the *C-59/R-72* combination in the oscillator grid circuit. Remove *J-64*, the power plug on the rear of the chassis. *(If the transmitter is going to be operated with a standard Command rack this plug should be left on the chassis.)* Remove all wiring below the chassis except the solid, tinned leads from the oscillator socket to the oscillator coil, *T-53*, the solid wires in the control grid leads of the p-a stage, and the wire from *C-62* to *T-53*.
2. Above the chassis, remove *K-54* and its wiring. Remove the antenna terminal and replace it with a coaxial fitting.

Fig. 5-13-I. This is a typical wiring schematic of the 274N series transmitters.

C-58—0.05/0.05/0.05 μfd., 300v.
C-59—175-185 μμfd.
C-60—air padder.
C-61—0.006 μfd., mica.
C-62—neutralizing condenser.
C-63, C-65, C-67—220 μμfd.
C-64—0.002 μfd., 1000v.
C-66—0.01 μfd., 2500v., mica.
C-68—3.0 μμfd., 750 p.p.m.
K-53—D.p.s.t. relay, 300-ohm coil.
K-54—S.p.d.t. antenna relay, 90-ohm coil.
R-67, R-75—51,000 ohms.
R-68, R-76—20 ohms.
R-69—1.0 megohm.
R-70—1000 to 1500 ohms.
R-71—126 ohms, 7w.
R-73—5100 to 15000 ohms.
R-74—15,000 ohms.
R-77—390 ohms.
R-78—51 ohms.
RL-50, RL-51—parasitic suppressors on 51-ohm resistors.



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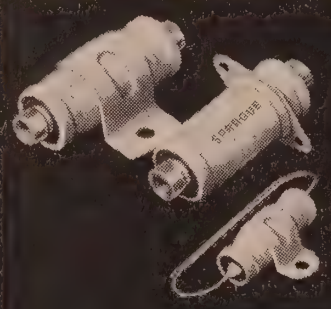

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(Amphenol 83-1R.) Connect the loading coil arm to the center pin of the coaxial fitting.

3. A 6J5 tube can directly replace the 1626 oscillator, and 807 tubes can replace the 1625 tubes in the p-a stage. To do this, the sockets for the 1625 tubes must be modified from seven-pin sockets to five-pin sockets to fit the 807's. This may be done as shown in *5-13-K*. *Holes 2, 4* and *6* should be filed out with a small "rat tail" file to accept the 807 base pins. Before any filing is done, the pin spring clips should be removed and the contacts spread apart to prevent damage to the clips during the filing operation. These clips should be replaced when the sockets have been modified.
4. Enlarge the rear power plug hole to 1¼" diameter, and mount an *Amphenol 86-CP6* six-prong socket in this hole. Before the socket is mounted, short lengths of No. 16 tinned wire should be soldered in each pin, and condensers *C4, C5, C6, C7* and *C14* connected to these wires. The condensers (and *pin 6*) are grounded to the socket mounting bolts. These condensers prevent spurious radiation through the power leads and greatly reduce TVI problems.
5. *C1* is mounted on the 6J5 socket between *pins 3* and *1*. *Pin 1* is grounded. *C2* is mounted on *pin 5* of *T-53*, counting from the rear pin towards the front of the transmitter. It is grounded to the soldering lug directly beside *pin 6*. *C8* is connected to *pin 4* of *T-53* and grounded by a lug placed under the adjacent chassis screw. *R2* and *R3* may be mounted by a small insulated terminal strip placed on the side wall of the chassis in the space formerly occupied by *C-64*, the old screen bypass condenser.
6. *C3, C9, C10, C11* and *C12* are connected directly to the pins of the 807 tube sockets. The ground leads of these condensers should be soldered to the frame of padding condenser *C-67* directly below the socket pins. It is very important that these condenser leads should be short.
7. *C13* and *RFC1* are mounted just below the insulated bushing through which the B plus lead from *T-54* passes. Note that both *C13* and *C7* are special high-voltage *ceramicon* condensers. As a final step, a closed circuit jack, *J1* is mounted in the lower left corner of the front pane.

The rotatable loading coil, *L-52*, is left in the circuit to permit the use of the transmitter with a wire antenna, but it should be set at zero for operation of the transmitter into a coaxial line.

If it is found impossible to load the transmitter to as high a value of plate current as desired, the small rotating pickup coil, *T-54B*, may be removed from the p-a tank assembly and rewound with more turns of wire. This will allow greater coupling between the transmitter and the antenna.

Testing and Alignment

The transmitter wiring should be checked. Six volts should be applied to *pins 1* and *6* of *P1* and 200 volts d.c. to *pin 2*. The oscillator should be checked on a nearby receiver and *C-60* reset, if necessary, for correct coverage of 80 or 40 meters. Plate and screen voltages should be applied to the 807 stage, and condenser *C-67* in the p-a stage re-resonated and locked. This adjustment should be made in the middle of the

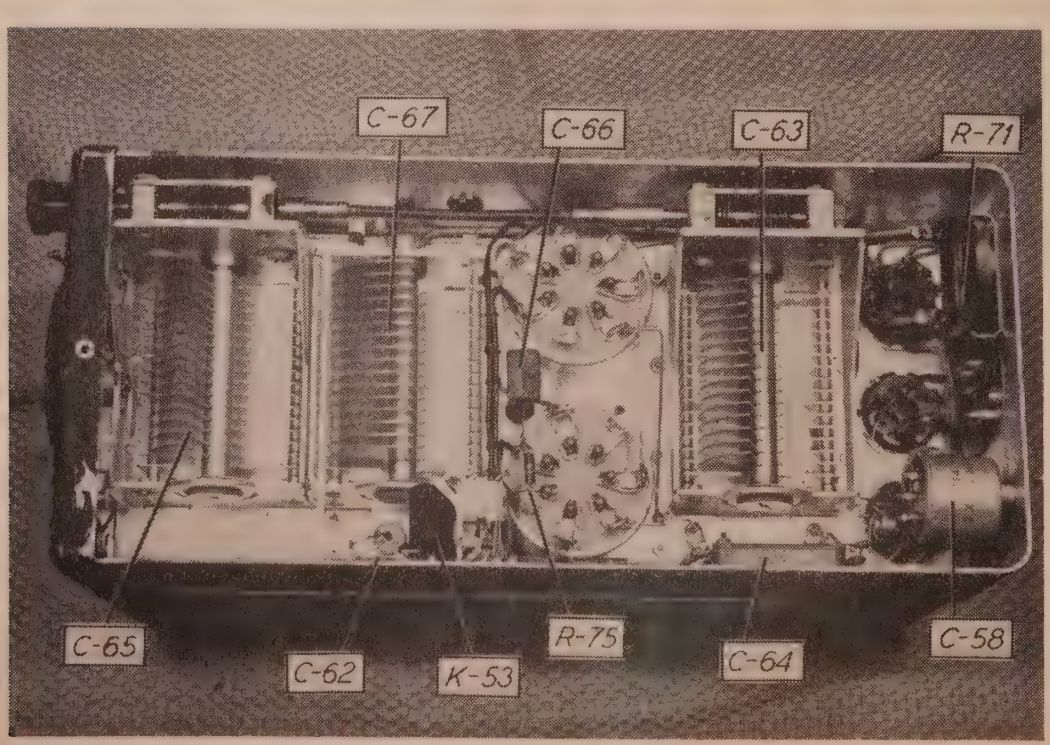

Fig. 5-13-H. Bottom view of a typical Command type war surplus transmitter showing the location of some of the important components.

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132	Double Tapered—Spring Swivel Base	8.75
132X	Heavy Duty—Double Tapered—Spring Swivel Base	9.85
132C	Double Tapered Spring—Swivel Base—W/Coax. Con.	8.75
132XC	Hvy. Duty—Dble. Tap. Spg.—Swiv. Base—W/Coax. Con.	9.85
132S	Stainless Steel—Double Tapered—Spring Swivel Base	10.75
132XS	Hvy. Duty Stainless Steel—Dbl. Tap.—Spg. Swivel Base	11.85
132SC	Stain. Steel—Dbl. Tap. Spg.—Swiv. Base—W/Coax. Con.	10.75
132XSC	Heavy Duty Stainless Steel—Double Tapered Spring—Swivel Base—With Coaxial Connector	11.85

Model	Bumper Mount Type	Net Price
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138X	Heavy Duty—Straight Spring	7.65
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140S	Stainless Steel—Double Tapered Spring	8.65
140XS	Heavy Duty Stainless Steel—Double Tapered Spring	9.65
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*X—Heavy Duty, C—Coaxial Type, S—Stainless Steel.

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100-86S	86"	Threaded 3/8" Stud to fit all Mounts	5.15
100-90S	90"	Threaded 3/8" Stud to fit all Mounts	5.20
100-96S	96"	Threaded 3/8" Stud to fit all Mounts	5.25
106-60S	60"	Plain End 3/16" Dia. (Fits Model 92 Ext.)	4.15
106-72S	72"	Plain End 3/16" Dia. (Fits Model 92 Ext.)	4.15
106-78S	78"	Plain End 3/16" Dia. (Fits Model 92 Ext.)	4.20
106-86S	86"	Plain End 3/16" Dia. (Fits Model 92 Ext.)	4.35
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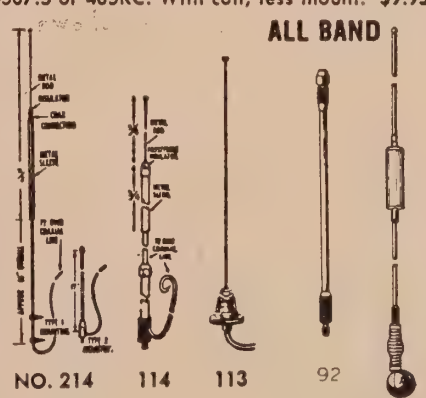

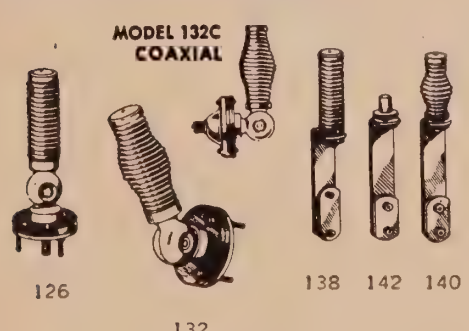

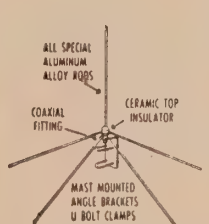

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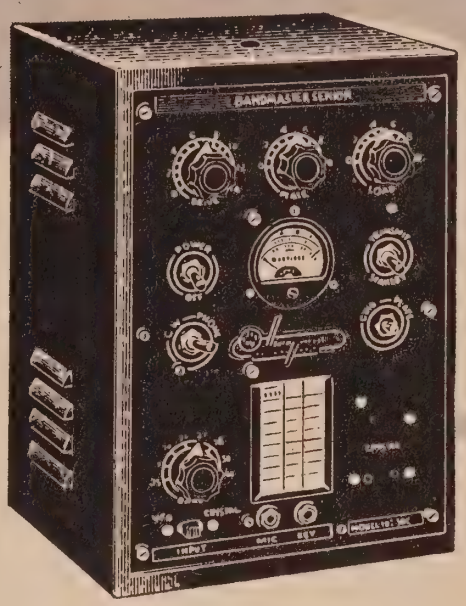

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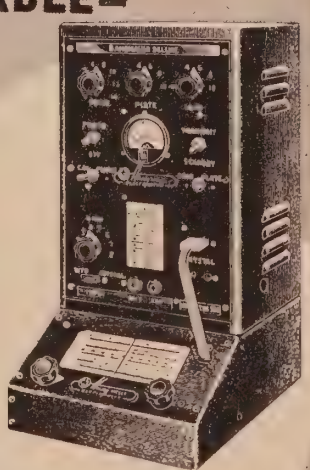

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Fig. 5-13-K. The 1625 sockets must be modified for use with 807 tubes. This is done by filing holes to sockets terminals 2, 4 and 6 so that they will accept the 807 pins.

amateur band. The slug of *T-54* may be adjusted if the two stages do not track properly across the band. The transmitter may now be connected to a suitable antenna and loaded up to a cathode current of 225 ma, measured in *J1*. Screen voltage should be set at 250 volts.

As a final adjustment, a 0-50 ma. meter should be connected between *pins 5* and *6* of *P1* and the grid current of the 807 tubes measured. The plate voltage of the 6J5 oscillator should then be adjusted until a grid current of 8 ma. flows under operating conditions. The plate voltage on the 6J5 will be about 180-220 volts when this adjustment is completed. The transmitter is now ready for installation in the car.

80 Meter Notes—

Either the *BC-696* (3.0-4.0 Mc.) or the *BC-457* (4.0-5.3 Mc.) transmitter may be used for 80-meter operation. The dial of the *BC-696* is directly calibrated for the 80-meter band, but this disadvantage is outweighed by the high surplus price of this unit. Actually, the *BC-457* is much better suited to 80-meter phone operation than is the *BC-696*. The *BC-457* will actually cover the top 60 kc. of the 80-meter phone band (3940-4000 kc.) without any adjustment of the padding condensers. The L/C ratio of the *BC-457* is also much more nearly correct for amplitude modulation of the p-a stage than is the *BC-696*. The *BC-457* tunes the 80-meter phone band with almost 350 $\mu\mu$fd. of tank capacity, whereas the *BC-696* tunes the same range with only about 150 $\mu\mu$fd. of tank capacity. Under heavy modulation, the *BC-696* tends to splatter badly, due to insufficient "fly-wheel" effect in the p-a tank circuit.

The *BC-457* may be easily shifted to cover the complete 80-meter phone band by increasing the capacity of *C-67*, the p-a padding condenser, and *C-60*, the oscillator padding condenser. The slug adjustments of the oscillator and p-a coils should not be changed, as this would alter the tracking of the transmitter.

40 Meter Notes—

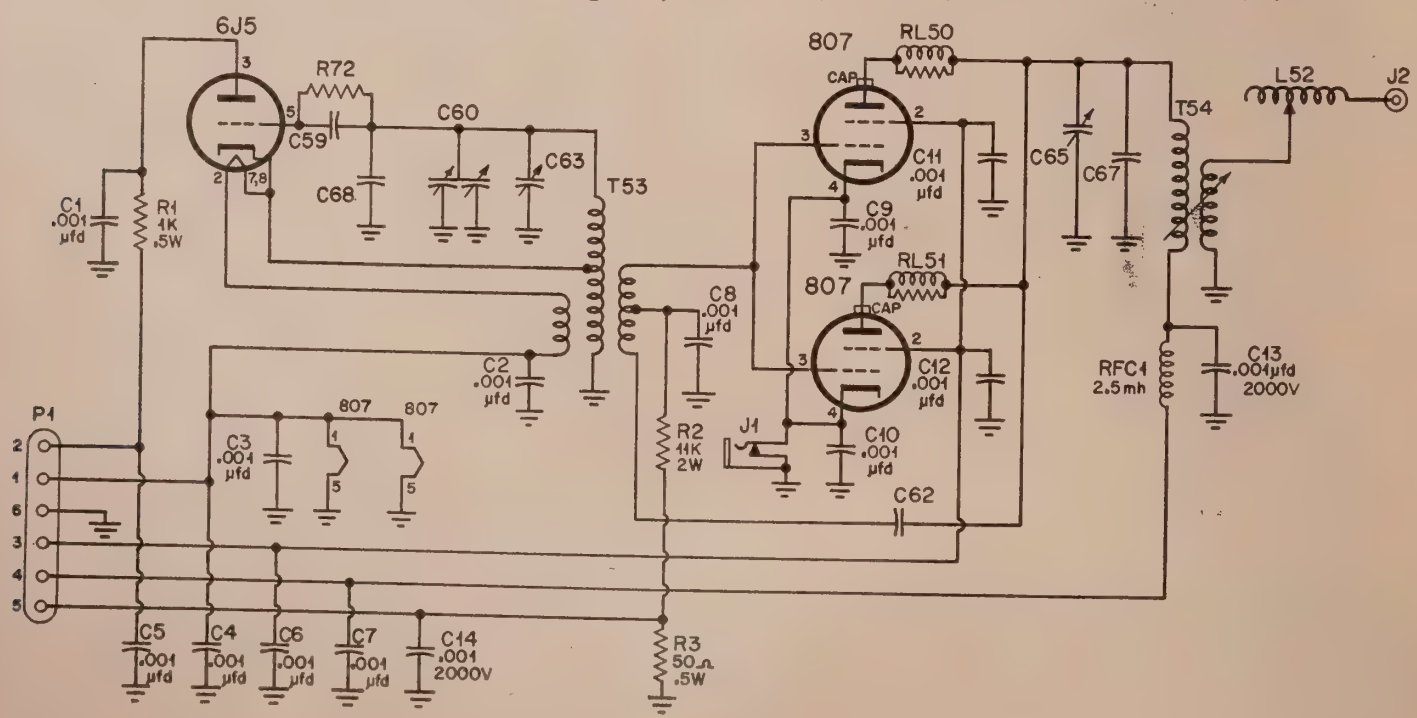
Either the *BC-459* (7.0-9.1 Mc.) or the *BC-458* (5.3-7.0 Mc.) may be used for 40-meter operation. The L/C ratio in the p-a tank of either transmitter is satisfactory for phone operation. The conversion of the *BC-459* is exactly the same as described for the *BC-696* on 80 meters *(Fig. 5-13-J)*.

The *BC-458* modification is the same as that of the *BC-459*, with the addition of retuning the tank circuits to make the transmitter tune the 7.0-7.3 Mc. range.

The *BC-458* oscillator can easily reach 7.3 Mc. by decreasing the capacity of *C-60*, the oscillator padding condenser. However, this is a poor approach, since it degrades the high C/L ratio of the oscillator. It is best to remove the oscillator coil shield and remove 4 turns from the top end of the oscillator coil. Next, loosen the set screws holding the rotor shaft of *C-60*. Drill a ¼" hole in the side of the shield can so that

Fig. 5-13-J. Transmitter modification to either 80 or 40 meters. Step-by-step details appear on page 176. All components without a par's value are the same as shown in Fig. 5-13-1.

C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C15—0.001 μfd., ceramicon, Erie 801-001.
C13, C14—0.001 μfd., ceramicon, 2000wv.
R1—1000 ohms, ½w.
R2—11,000 ohms, 2w.
R3—50 ohms, ½w.
J1—jack, closed circuit, ICA 1871.
J2—coaxial connecter, Amphenol 83-1R.
P1—socket, Amphenol 86-CP6.
RFC1—2.5 mh, National R-100U.



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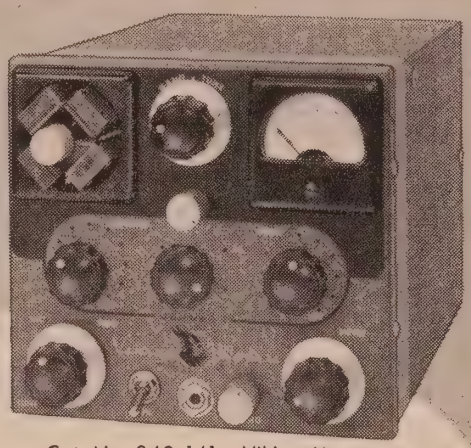

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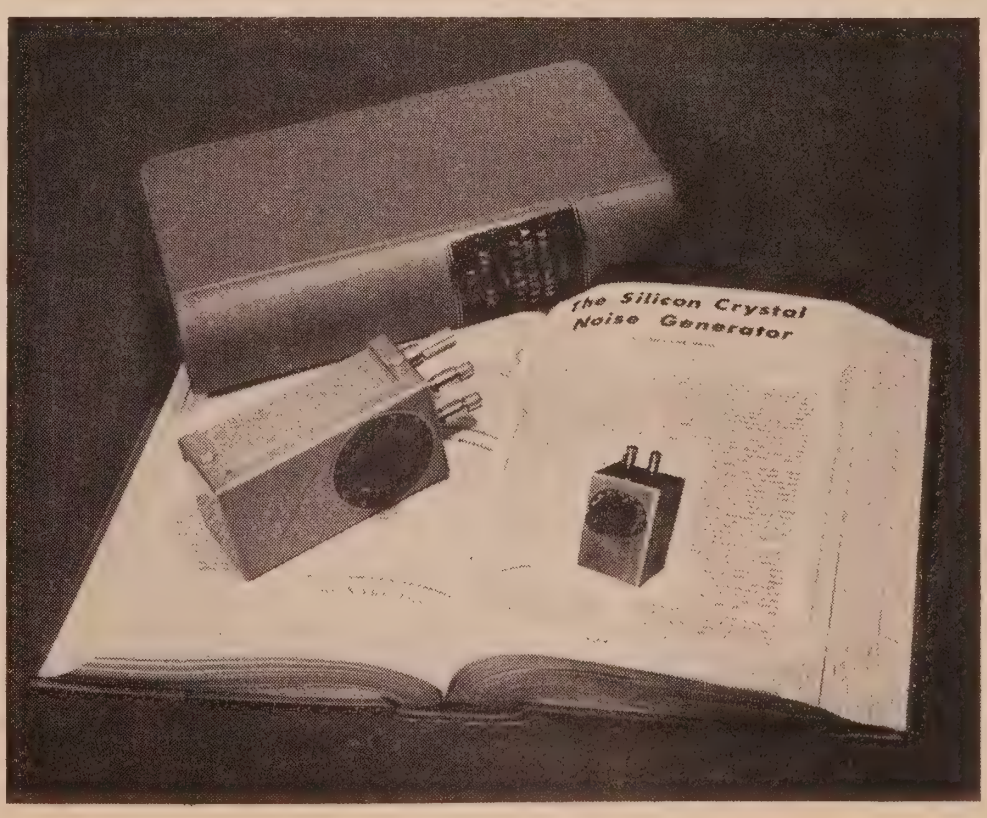


the shaft can be turned when the shield is replaced. Remove two plates from the rotor of *C-63*, the oscillator tuning condenser. Flex the plates gently with long-nosed pliers. If too much force is applied to the condenser, the rotor will jump out of its bearings, and the minute ball bearings will fall out of the joint. Remove two rotor plates in the same fashion from *C-65*, the p-a tuning condenser. Loosen the rotor lock on *C-67*, the p-a padding condenser. Finally, remove four turns from the top of the p-a coil, *T-54A*.

Plate voltage should be applied to the 6J5 oscillator, and *C-60* and the slug of *T-53* adjusted until 7.0 Mc. falls at 6.0 Mc. on the tuning dial, and 7.3 Mc. falls at 6.3 Mc. Thus the calibration will be correct if 1.0 Mc. is mentally added to the dial reading.

Plate and screen voltage should be applied to the p-a stage. The transmitter should be tuned to 7.2 Mc. and loaded to the antenna. The p-a padding condenser *C-67* should be resonated for minimum plate current and then locked. *C-65* should always be re-resonated whenever there is a major change in antenna loading or coupling.

Transmitter Conversion for 20, 15 and 10 Meters

The conversion of the 4.0-5.3 Mc. transmitter for high frequency use is based upon retaining single dial control and the use of only one doubler stage.

The space left by the removal of the electron eye tube and the calibrating crystal may be used for a 6AG7 doubler and a slug tuned coil. The basic circuit for 20, 15 and 10 meters is shown in *Fig. 5-13-L.*

The basic filament and socket modifications as described for the low frequency units should be completed. For 20 and 15 meters, the 6J5 oscillator must work in the 7-Mc band, using the existing dial calibration lines, with new figures. The main winding of the oscillator coil should be reduced to 12 turns, by removing turns from the top of the coil. The oscillator tuning condenser, *C-63*, should have all but two rotor plates removed. One of the remaining plates should be the slotted one for tracking adjustment.

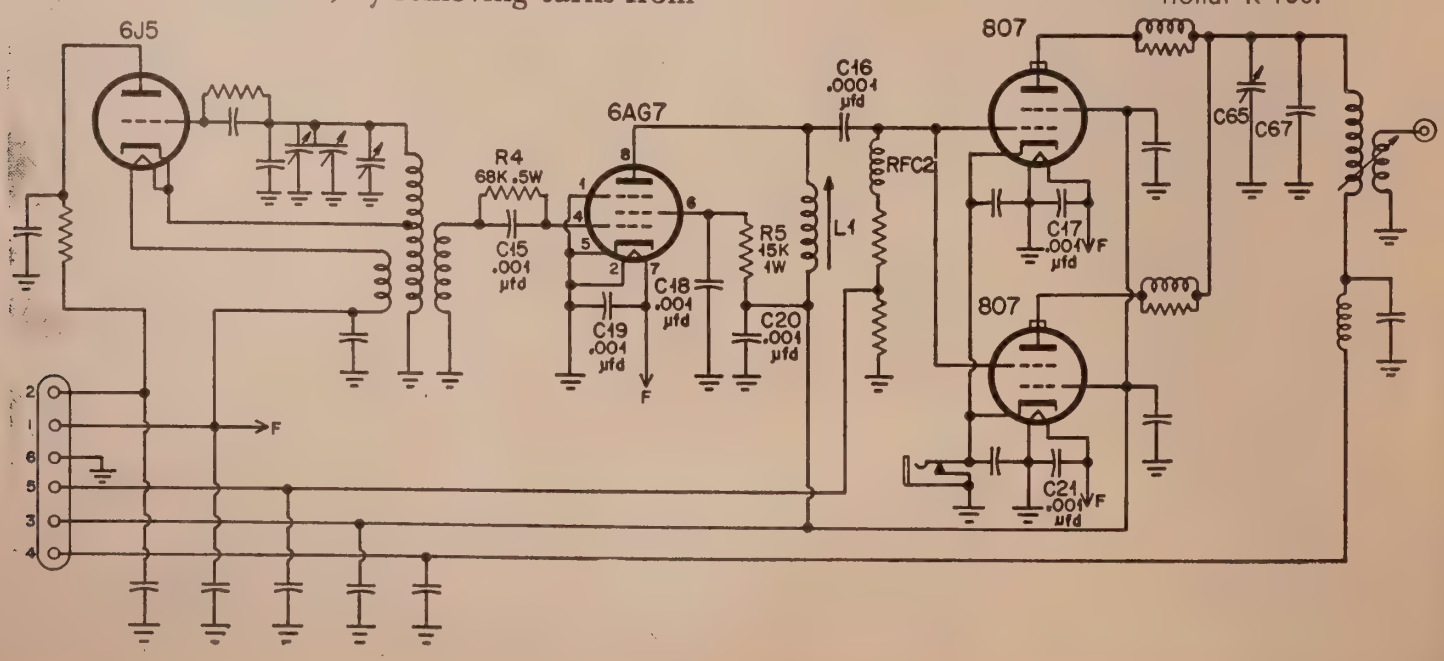
At the oscillator coil terminals under the chassis, *C-62* (the neutralizing condenser) should be removed and the bias return of the doubler stage moved from the center tap of the coil to the free end.

An octal socket is replaced in the crystal calibrator socket hole. The electron eye socket hole is covered by a small metal plate. A *National XR-50* slug tuned coil is mounted in the center of this plate with its slug adjustment above the chassis. This coil *(L1)* is wound with 10 turns of No. 24 enamelled wire, spaced to occupy the full winding length. Condenser *C16* connects to the "hot" end of *L1* and is supported on its free end by a small ceramic standoff insulator. *C19* and *C18* mount directly on the 6AG7 socket. *C20* connects between the "cold" end of *L1* and the coil mounting lug. *RFC2* and the bias resistors mount on the side of the chassis, just about where *K-53* was located.

The p-a plate coil, *T-54*, is rewound with its own wire, using 5½ turns, double spacing them in the existing grooves. Remove all but two rotor plates from both the p-a tuning condenser, *C-65*, and the p-a loading condenser, *C-67*. The rotary antenna loading coil may be left in the circuit, but should be set at zero for coaxial feed.

Fig. 5-13-L. To modify the transmitter to operate on 20 meters and below an extra doubler stage is required.

C15, C17, C18, C19, C20—0.001 μfd., ceramicon, Erie 801-001.
C16—0.0001 μfd., ceramicon.
L1—at 14 Mc., 10 turns #24 enam., ½-inch long on XR-50.
at 21 Mc., 7 turns #24 enam., ½-inch long on XR50.
at 28 Mc., 5 turns #24 enam., ½-inch long on XR-50.
R4—68,000 ohms, ½w.
R5—15,000 ohms, 1w.
RFC2—2.5 mh., National R-100.



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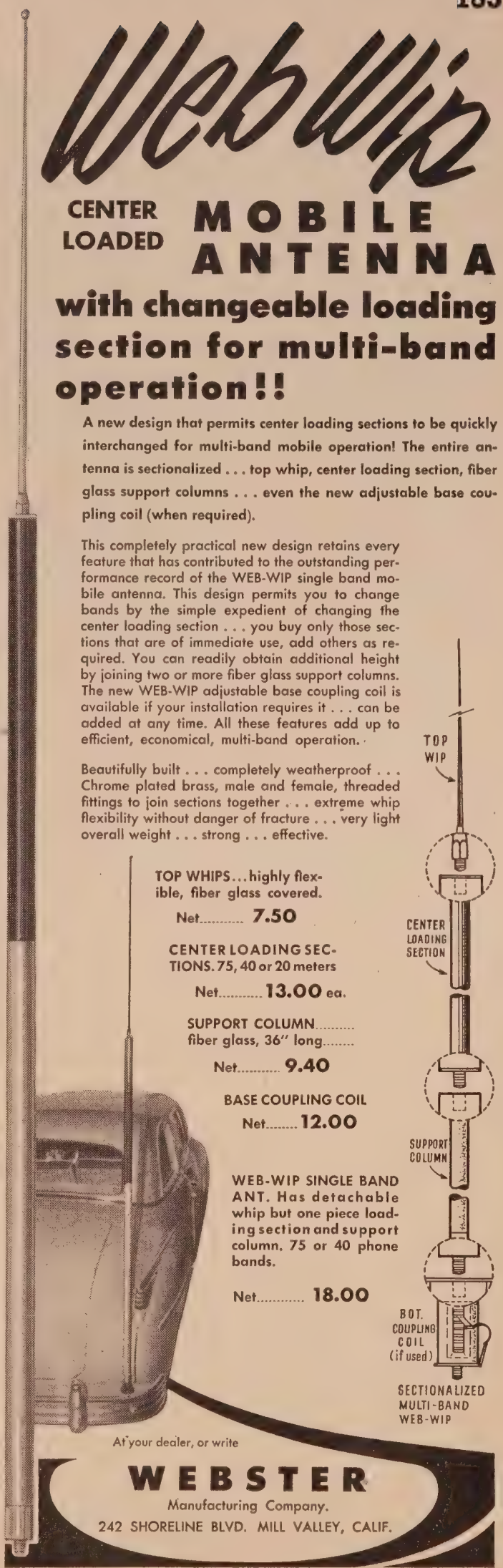

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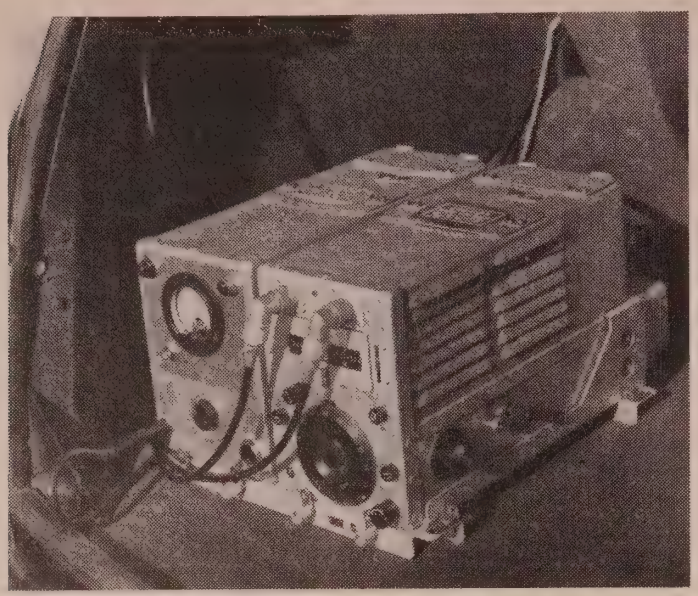

Fig. 5-13-N. The late W2CVV used this arrangement in the trunk of his automobile.

Power should be applied to the oscillator and doubler. *C-60* should be adjusted until the oscillator covers 7.0-7.2 Mc. The slotted plate in *C-63* may be adjusted until the range tracks with the dial markings. 14 Mc. falling at 4.0 on the dial, and 14.4 Mc. falling at 4.8 on the dial. Thus each dial division is equal to 5 kc. at 20 meters.

Apply 250 volts to the screens of the 807's and the chosen value of plate voltage. Resonate the p-a tank circuit to 14 Mc. by tuning the padding condenser, *C-67,* under the chassis. Some slight adjustment of the p-a slug in *T-54* may be necessary for perfect tracking. Peak the 6AG7 plate coil and replace the top and bottom shield plates.

For 15 meters, the 6AG7 stage operates as a tripler from 7 Mc. The coil, *L1,* has 7 turns of No. 24 enam. wire spaced to occupy the winding length. For this band the ganged condenser, *C-65,* in the p-a stage is not used. All p-a tuning is done by *C-67,* the padding condenser. As for 20 meters, *C-63* and *C-67* are reduced to two plates. *C-67* may be adjusted by a screwdriver through the side of the case, or an extension shaft and knob may be placed on it. The p-a coil, *T-54,* is rewound to 4 turns, double-spaced located near the center of the coil form for best coupling to the variable link inside the ceramic form.

For 10 meters, the 6J5 oscillator is brought to 14 Mc., and the 6AG7 operates as a doubler to 28 Mc. The stability of the oscillator is still very good at this high frequency.

The modifications are made as for 20 meters. The doubler coil consists of 5 turns of No. 24 enam. wire on the *XR-50* form. The oscillator coil, *T-53* is modified as follows: Remove turns from the top of the coil, leaving 1⅔ turns above the cathode tap. Remove turns from below the cathode tap, leaving only 4 turns below the tap. Be careful not to damage the filament winding interwound with the grid coil. Remove 4 turns from the bottom of the filament winding. This should be done by cutting a turn, removing turns, then splicing the wires together again. Remove all but 3 rotor plates from the oscillator tuning condenser, *C-63,* and all but 7 rotor plates from the oscillator padding condenser, *C-60.*

The plate coil, *T-54,* must be removed for 10-meter operation. A new coil, consisting of 5 turns of No. 12 enamelled wire, 1″ long and 1″ diameter is wound on a *Millen 45000* coil form, which is bolted to the chassis in front of the 807's, in approximately the location of the old coil.

The ganged p-a tuning condenser, *C-65* is unused. The padding condenser, *C-67,* is cut down to *5 rotor* and *6 stator plates* and used as the tuning condenser for the new coil. Its shaft may be extended through the side of the case, if desired, or it may be screwdriver tuned and locked. The small parasitic suppressors should be removed from the old coil and reused in the 807 plate leads.

An antenna link should be wound consisting of 3 turns of No. 12 enamelled wire, 1¼″ diameter and should be mounted on standoff insulator to slip over the plate coil. Once adjusted for proper loading, it may be fixed in position and left alone. For ease of loading, a 100 $\mu\mu$fd. variable condenser should be placed in series with the antenna coil.

Apply plate voltage to the oscillator and doubler and adjust the oscillator to 14.5 Mc. by listening on the station receiver. The doubler should then be tuned to 29 Mc. It is simpler in this case to disregard dial markings, and recalibrate the whole dial once the oscillator has been adjusted. Apply plate and screen voltage to the 807's and tune the p-a tank to resonance. Replace the top and bottom shields, peak up the doubler, check the oscillator frequency and calibrate the dial from 28.0 Mc. to 29.7 Mc. The conversion is now complete.

The Modulator

The Command transmitters described above will perform in an excellent manner with a plate supply of 500 to 600 volts. Using a surplus *PE-103A* dynamotor, they are capable of an input of 60 watts to the final amplifier, with 100% modulation. From a fixed location using a plate supply of 600 volts at 200 ma., they are capable of 100 to 120 watts input.

The modulator described here will fully modulate up to 120 watts input to the transmitter. At the same time, it is economical for use with inputs as low as 30 or 40 watts, since the static plate current is lower than that of a single 6N7 tube, and only about one third the static plate current of a pair of class AB1 6L6's.

The modulator employs a pair of triode connected zero-bias 807 tubes, driven by a push-pull 6SN7 cathode follower *(Fig. 5-13-M).* The screens and grids of the 807's are connected together through a 22,000-ohm resistor and the drive is applied to the screen grids of the tubes. The

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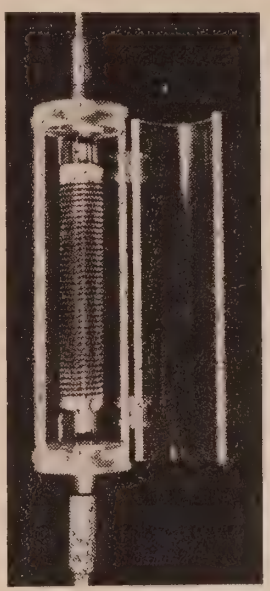

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static plate current is of the order of 8 ma. with this connection, but the cathode coupled driver supplies a positive grid bias of 10 volts to the 807's which raises the static plate current to 30 ma. This will increase to 80 to 150 ma., with tone modulation depending upon the amount of audio required. On voice, the average plate current peaks as read on the plate meter will run about 120 ma. for full output.

The necessary low impedance driving stage is supplied by the 6SN7 cathode follower. The total plate current required by the two driver tubes is less than 10 ma. at 250 volts. This may be obtained from a dropping resistor from the high voltage supply, or perhaps from the receiver plate supply, which may be switched from the receiver to the modulator during transmissions.

The plate-to-plate load of the modulator should be about 12,000 ohms, although the modulator will work well with plate loads as low as 4000 ohms. No change in plate impedances or bias is necessary with operating plate voltages in the region of 150 to 600 volts.

The entire modulator may be built on a stripped down *SCR-274N* chassis. The 1625 sockets may be modified to take 807 tubes, and the speech amplifier tubes may be mounted in the socket holes at the rear of the chassis. *T1* may be mounted beneath the VFO shield can. *Figure 5-13-N* shows the modulator mounted in a Command rack with a modified transmitter, and *Fig. 5-13-O* illustrates the placement of parts within the modulator unit.

A patch plate covers the top portion of the front panel, and mounts a 0-300 ma. meter which may be switched to read either modulator plate current or the final plate and screen current of the transmitter.

The gain control, *R6,* is mounted near the rear sockets on a small bracket and provided with an extension shaft to make it accessible from the front panel. A "Filament" and a "Transmit" pilot lamp may be mounted above the meter, if desired.

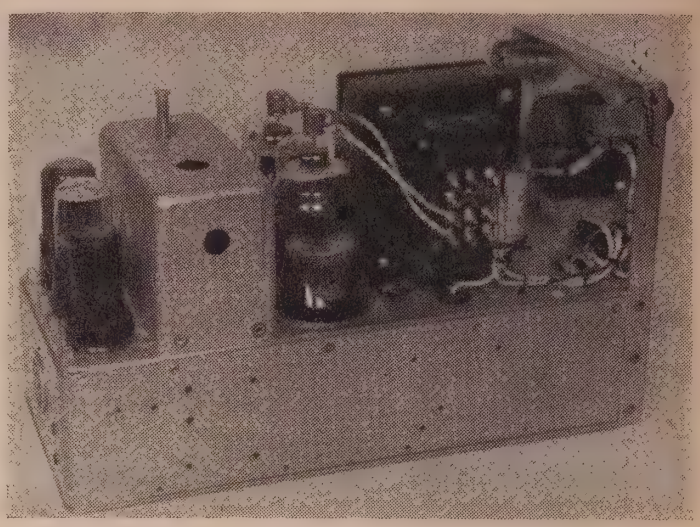


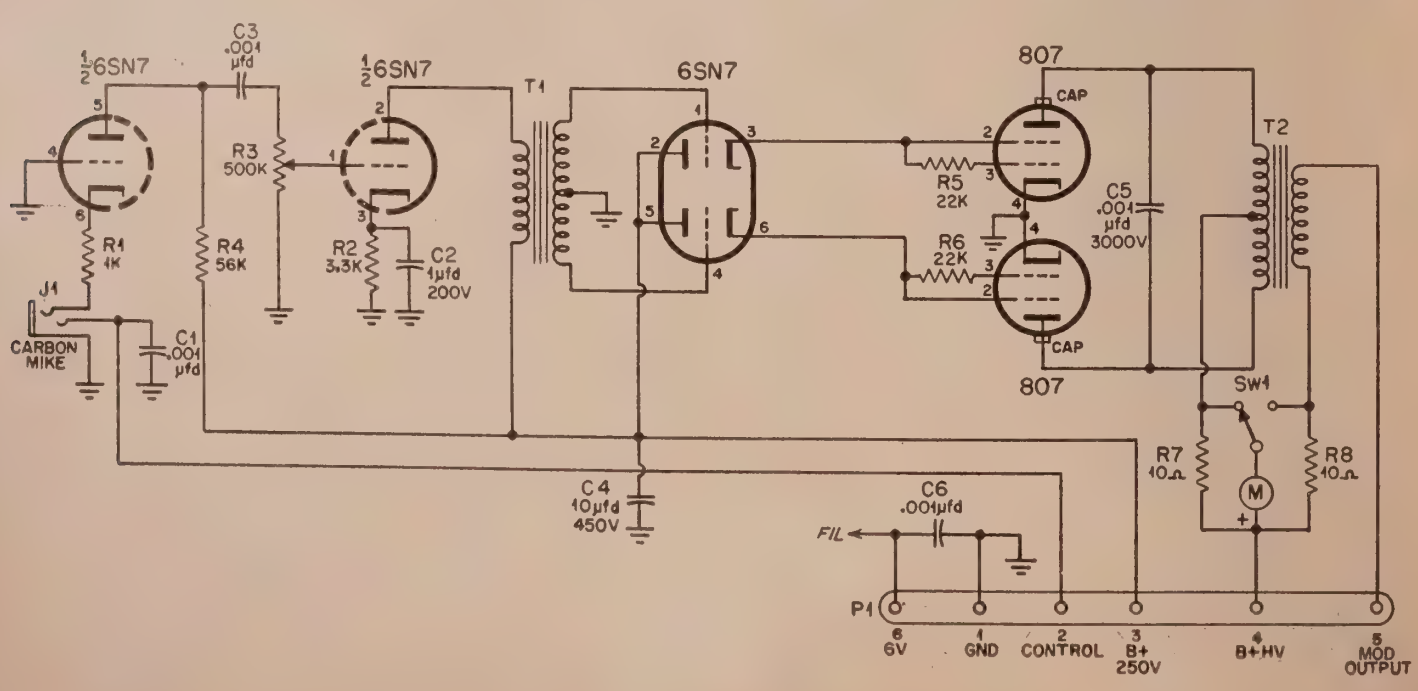
Fig. 5-13-O. Parts placement in the modulator built by W2CVV was found to be non-critical even for the high output.

Control Circuits

A typical control circuit for use of this modulator, with a *SCR-274N* transmitter and a *PE-103A* dynamotor is shown in *Fig. 2-6-E.* This circuit may easily be modified for use with other power supplies, if desired, by removal and substitution of the *PE-103A* power plug.

Fig. 5-13-M. This modulator will handle an input of 60 watts and yet maintain a relatively low static plate current.

C1, C3, C6—0.001 μfd., ceramicon, Erie 801-001.
C2—1.0 μfd., 200v., Sprague 2TM-M1.
C4—10.0 μfd., 450v., Sprague TVA-1705.
C5—0.001 μfd., 3000v., ceramic, Erie 3KV-102.
J1—two-circuit microphone jack, ICA 1922.
P1—chassis plug—Cinch-Jones P306-FP (use with cable socket 306-CCT).
R1—1000 ohms, 1/3w.
R2—3300 ohms, 1/3w.
R3—500,000-ohm potentiometer.
R4—56,000 ohms, 1/3w.
R5, R6—22,000 ohms, 1/3w.
R7, R8—10 ohms, 1/3w.
Sw1—S.p.d.t. toggle switch, ICA 1236.



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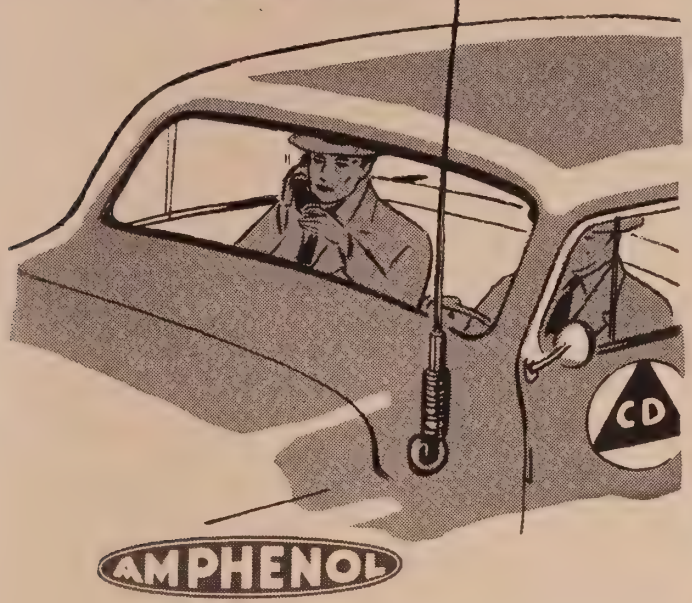

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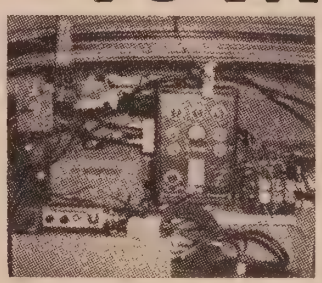

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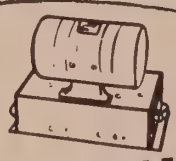

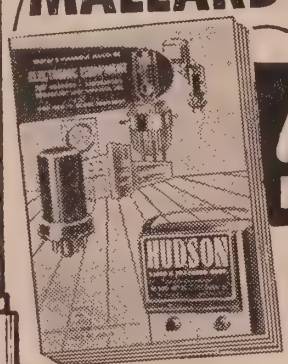

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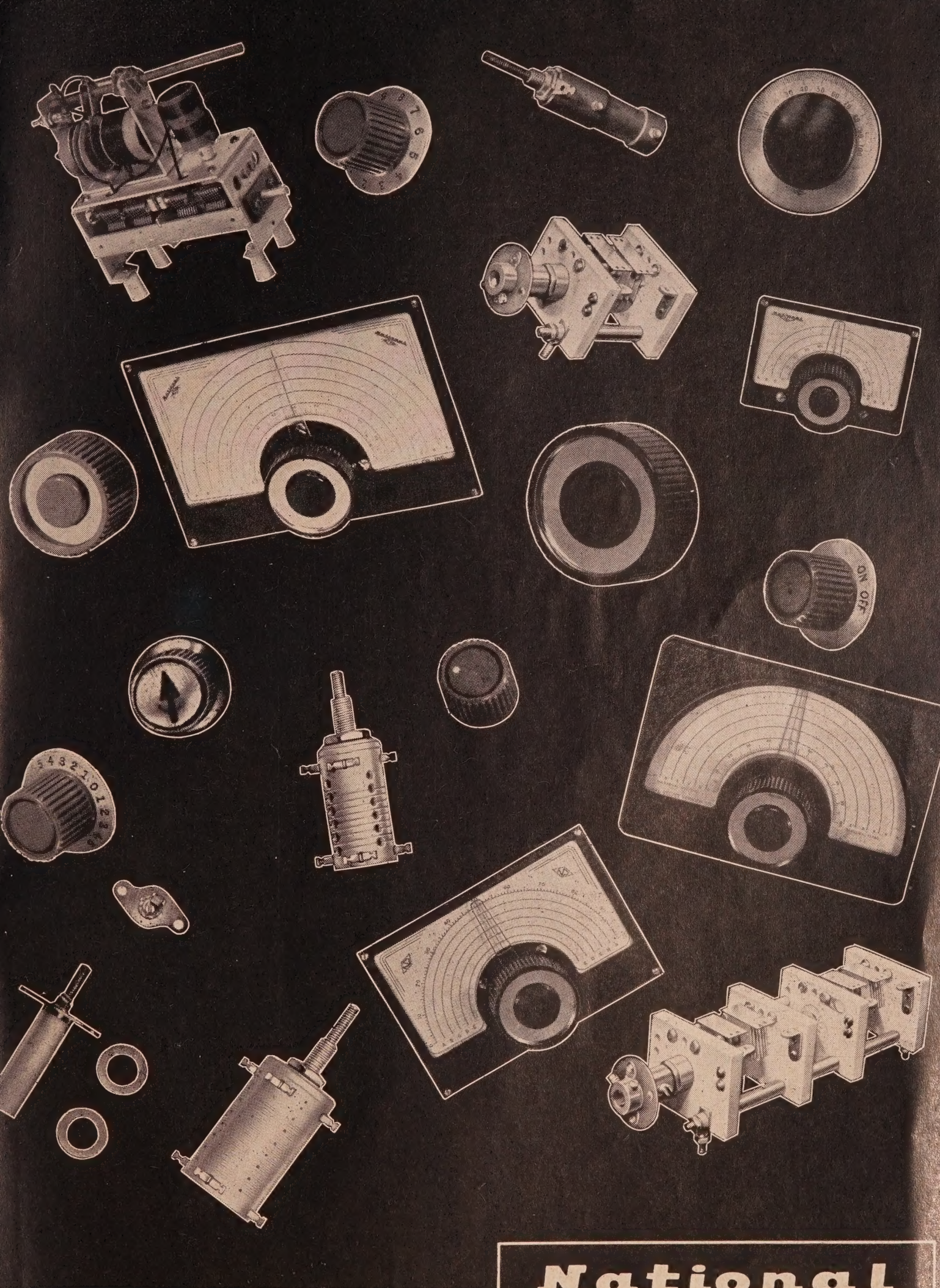

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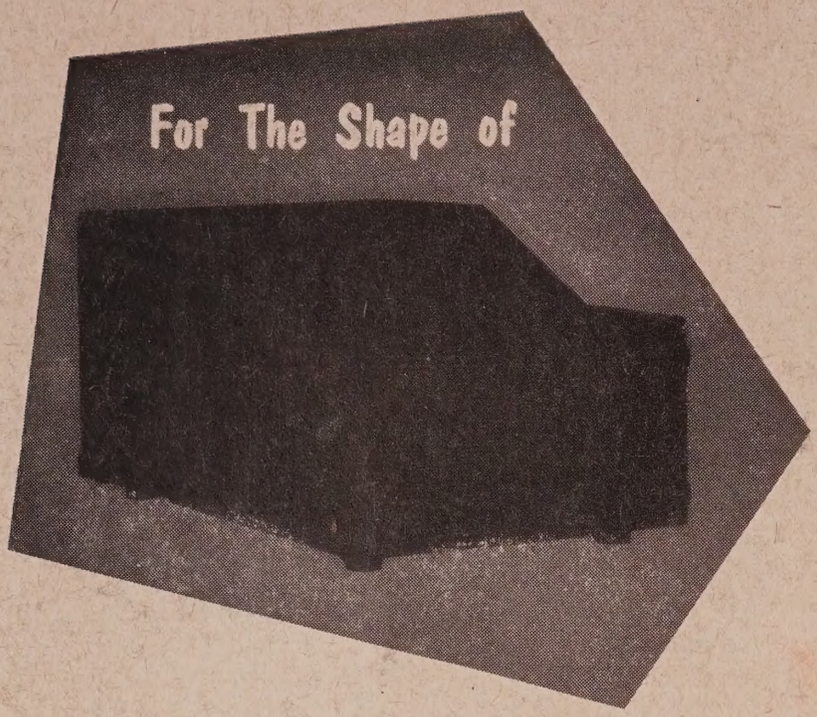

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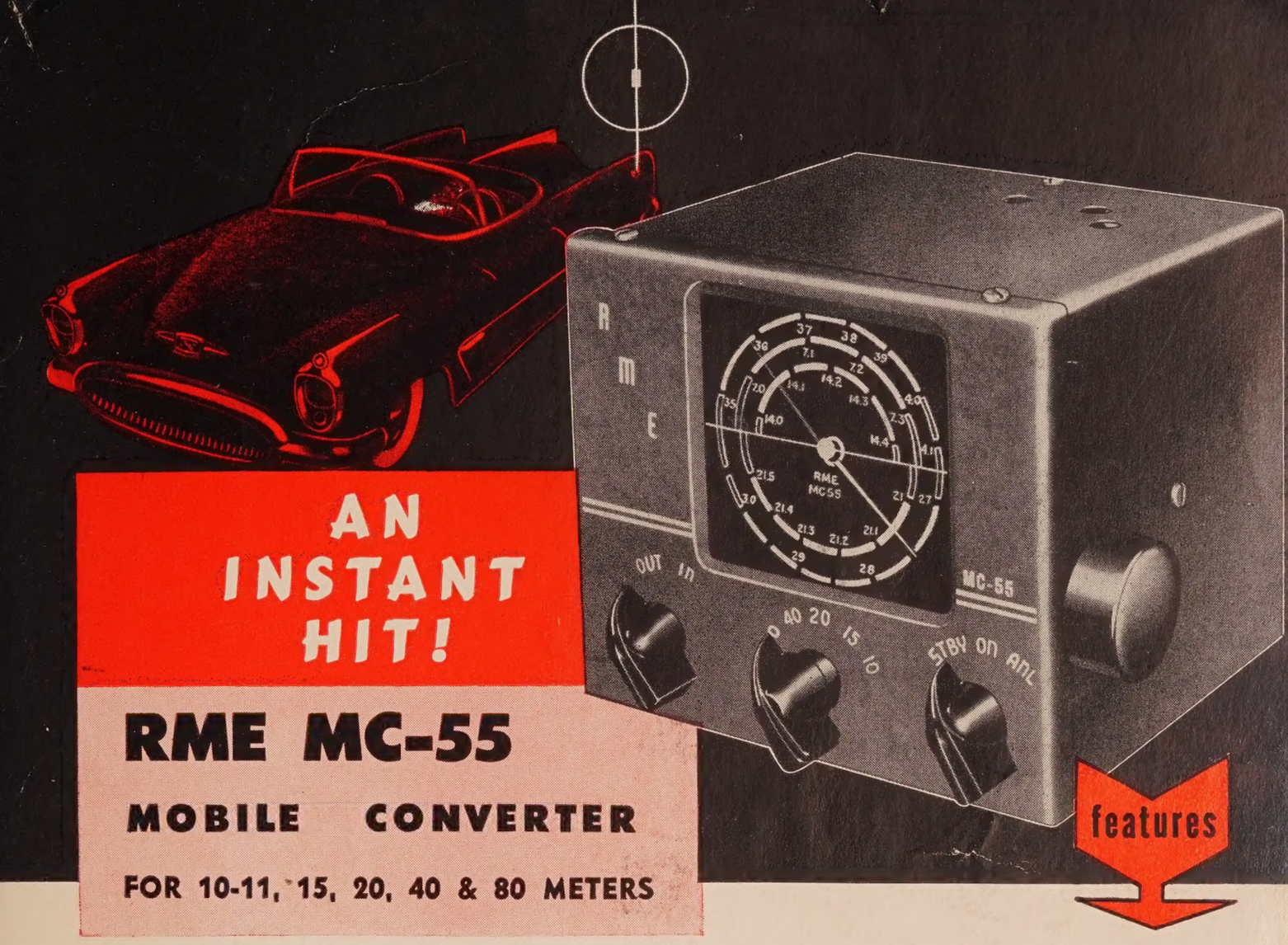

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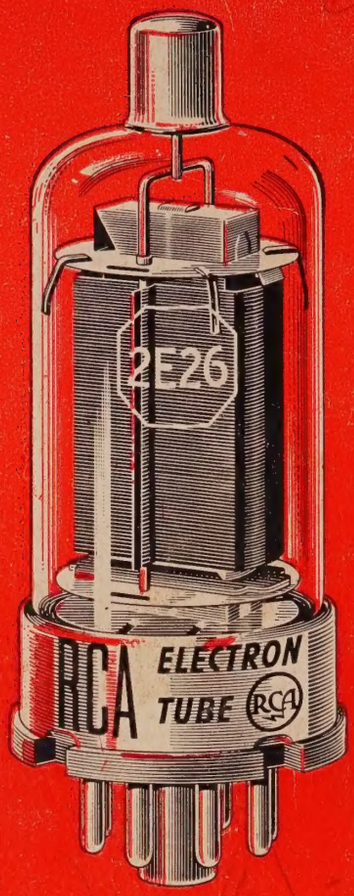

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